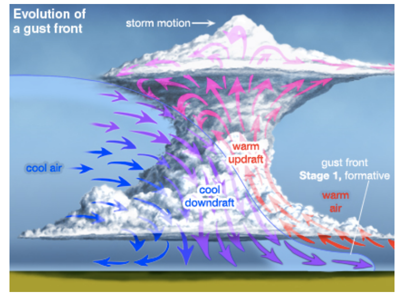
Homework–Module 4 **Name:** Key

1) We learned in Module #3 that adiabatic compression always works to warm sinking air. Yet a thunderstorm downdraft is usually colder than the air surrounding it. Explain the apparent paradox using concepts that are discussed in Chapter 10. There is a 600-character limit.

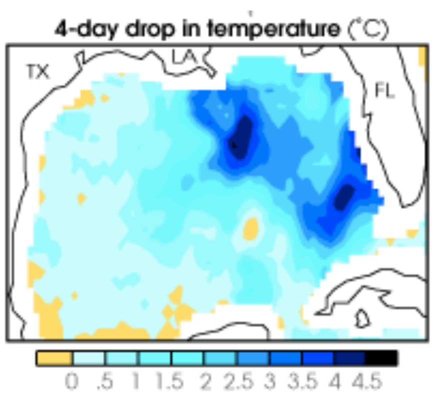


Cool downdraft in a severe thunderstorm.
Figure Credit: [Encyclopedia Brittanica, Inc.]

Thought progression:
- Raindrops begin to evaporate as they fall from the base of the cloud into unsaturated air.
- The rate of evaporative cooling (latent heat of vaporization) counteracts the rate of adiatbatic warming.
- Hence, the downdraft underneath the cloud is colder than the air that surrounds it.

Comment: the rate of evaporative cooling can be so great that the lapse rate in the descending air underneath the cloud base can approach the moist adiabatic lapse. This stands in stark contrast to the uprising, unsaturated air underneath the cloud base.

2) Explain why the ocean surface water temperatures are usually significantly cooler after the passage of an intense hurricane. The answer is not because the hurricane extracts heat from the water, a process that accounts for a smaller portion of the cooling. Think in terms of what the wind does to the surface water and water a few meters below the surface. You may want to revisit material in Chapter 3 on how wind affects the formation of the nighttime surface inversion and relevant material in Chapter 7 on how sea temperatures vary with depth before answering the question. There is a 600-character limit.



Satellite measured change in the surface water temperature (the top few millimeter of the ocean) four days after the passage of Hurricane Katrina. A cooling up to 4˚C occurred in regions where Katrina rapidly deepened.

Figure Credit: [NASA]

Thought progression:
- Water just below the surface is cooler than at the surface before the hurricane approaches.
- The wind agitates the sea surface and creates large waves.
- Breaking waves mix the surface water with cooler waters up to 30 m (100') below the surface.
- The mixing equilibrates temperatures by cooling the surface water while warming the subsurface water.

Less important reasons worthy of some credit:
- Evaporation of surface water and sensible heat transport from the water to the air (important, but not as big as vertical mixing). Very common answer.
- There is also weak upwelling that brings cooler water that is underneath the low pressure center to the surface. Another common answer.
- Lack of sunshine (very small).