AOS 630: Introduction to Atmospheric and Oceanic Physics

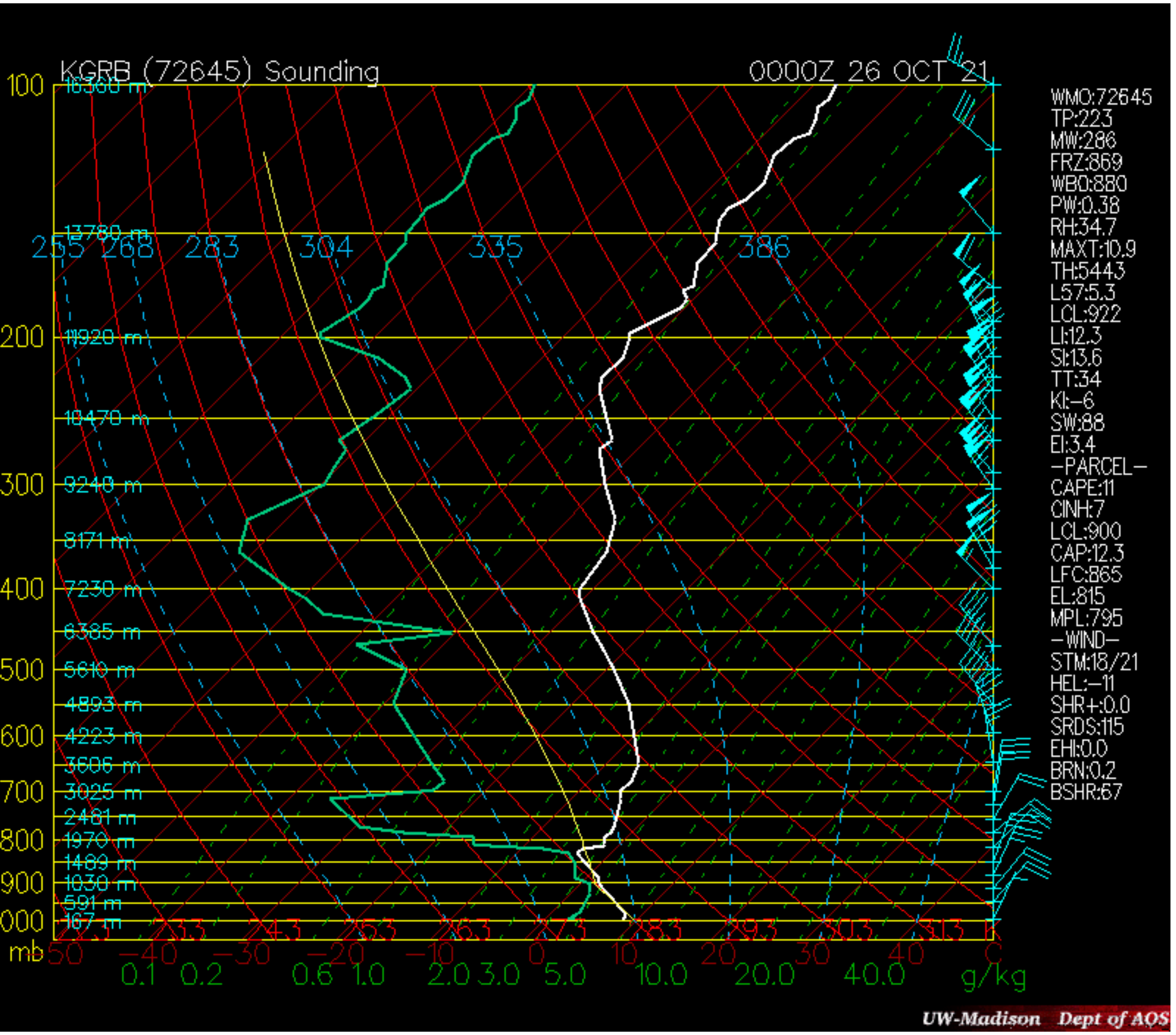
Lecture 14   Fall 2021

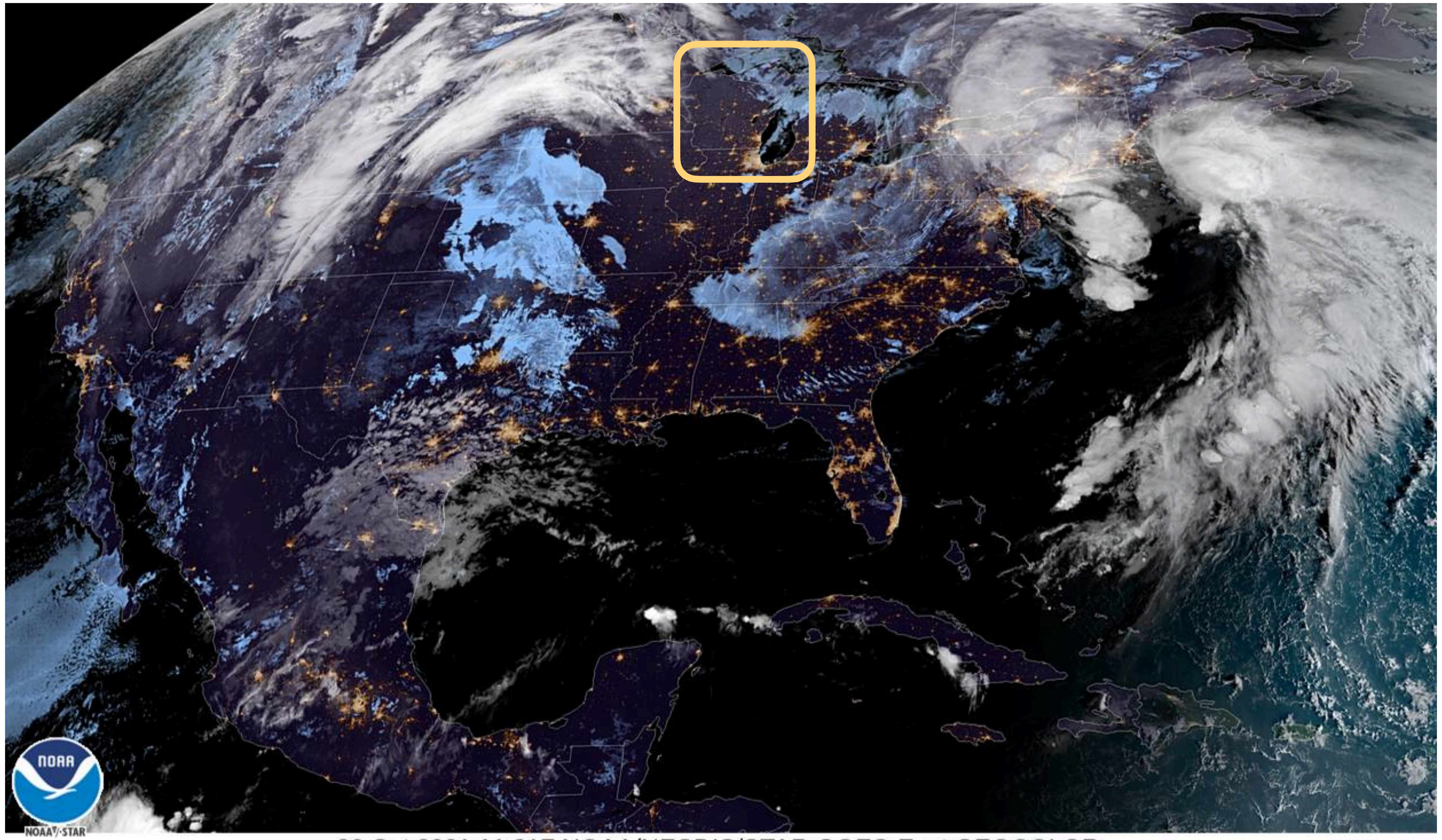
Moist adiabatic processes

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

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

Daily dose of thermo





26 Oct 2021 11:31Z NOAA/NESDIS/STAR GOES-East GEOCOLOR

Announcements

Make sure you select your topic for the final. You have until Thursday. A topic will be assigned to you otherwise.

https://docs.google.com/spreadsheets/d/1TCI-Y553alWn-WNA50XBKjlkDoXeS1Z_4g3nbuSmAek/edit?usp=sharing

HW3 is due Thursday. HW4 will be released then.

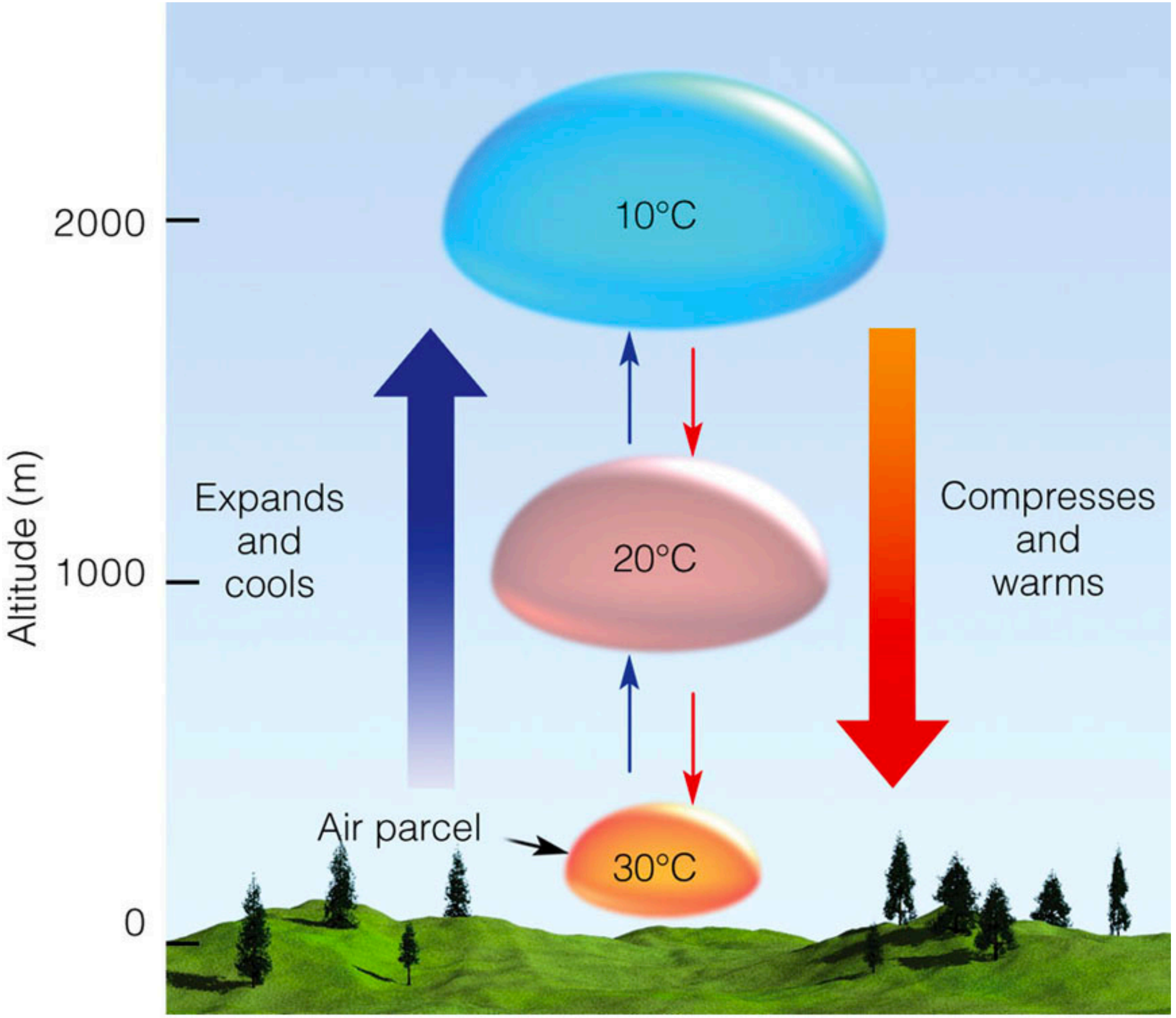
No Skew-T due today. A new one will be given today. Due next Tuesday.

Recap:

$$\theta = T\left(\frac{p_0}{p}\right)^{R_d/c_p}$$

The temperature a parcel would have if its adiabatically brought back to the surface.

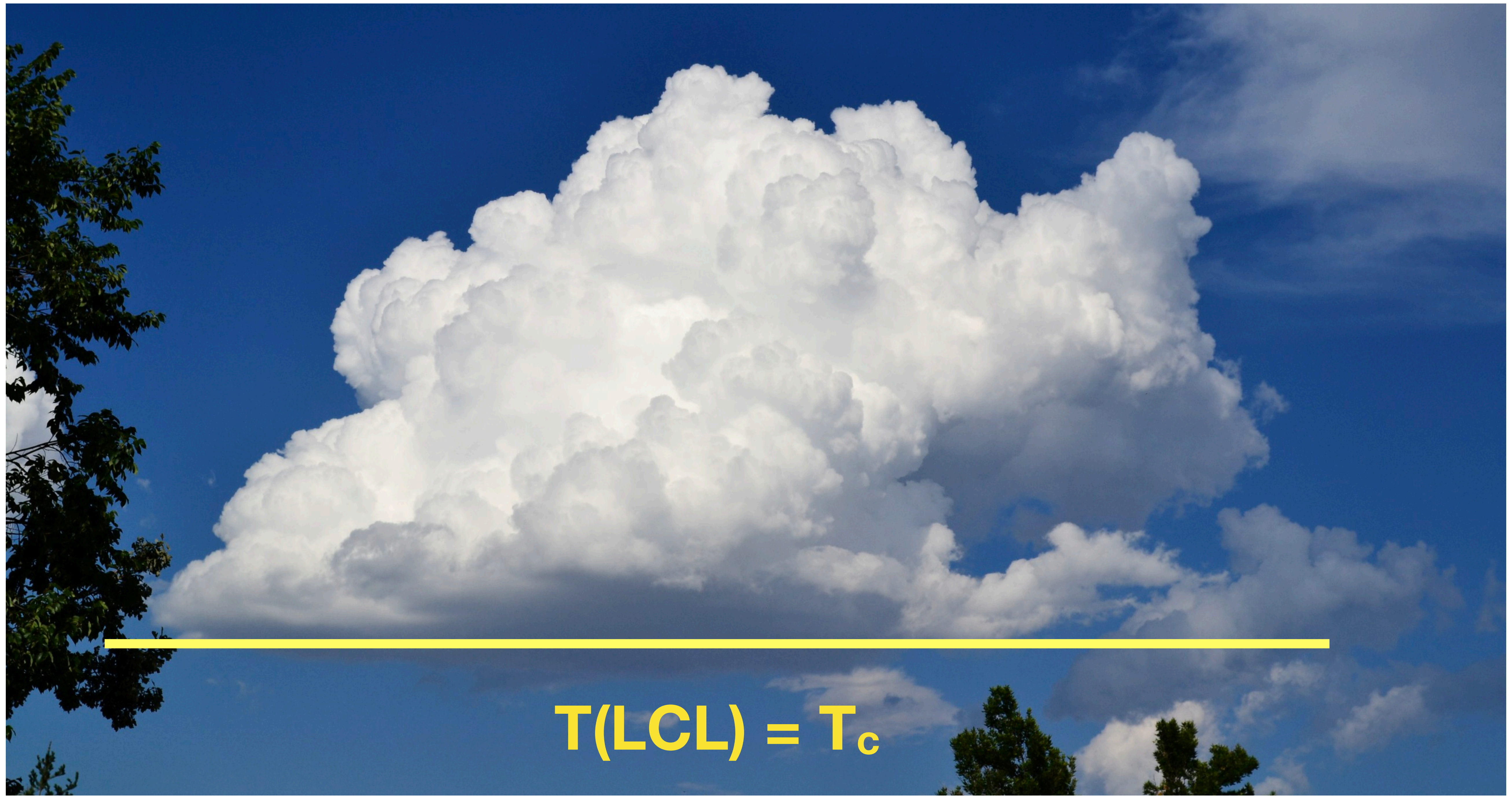
A parcels undergoing adiabatic expansion would conserved its potential temperature



Isentropic Condensation temperature

Once the parcel is lifted from the ground, it will rise dry adiabatically until it reaches the LCL.

At this point it reaches the saturation temperature of an adiabatic process, known as the "isentropic condensation temperature T_c".



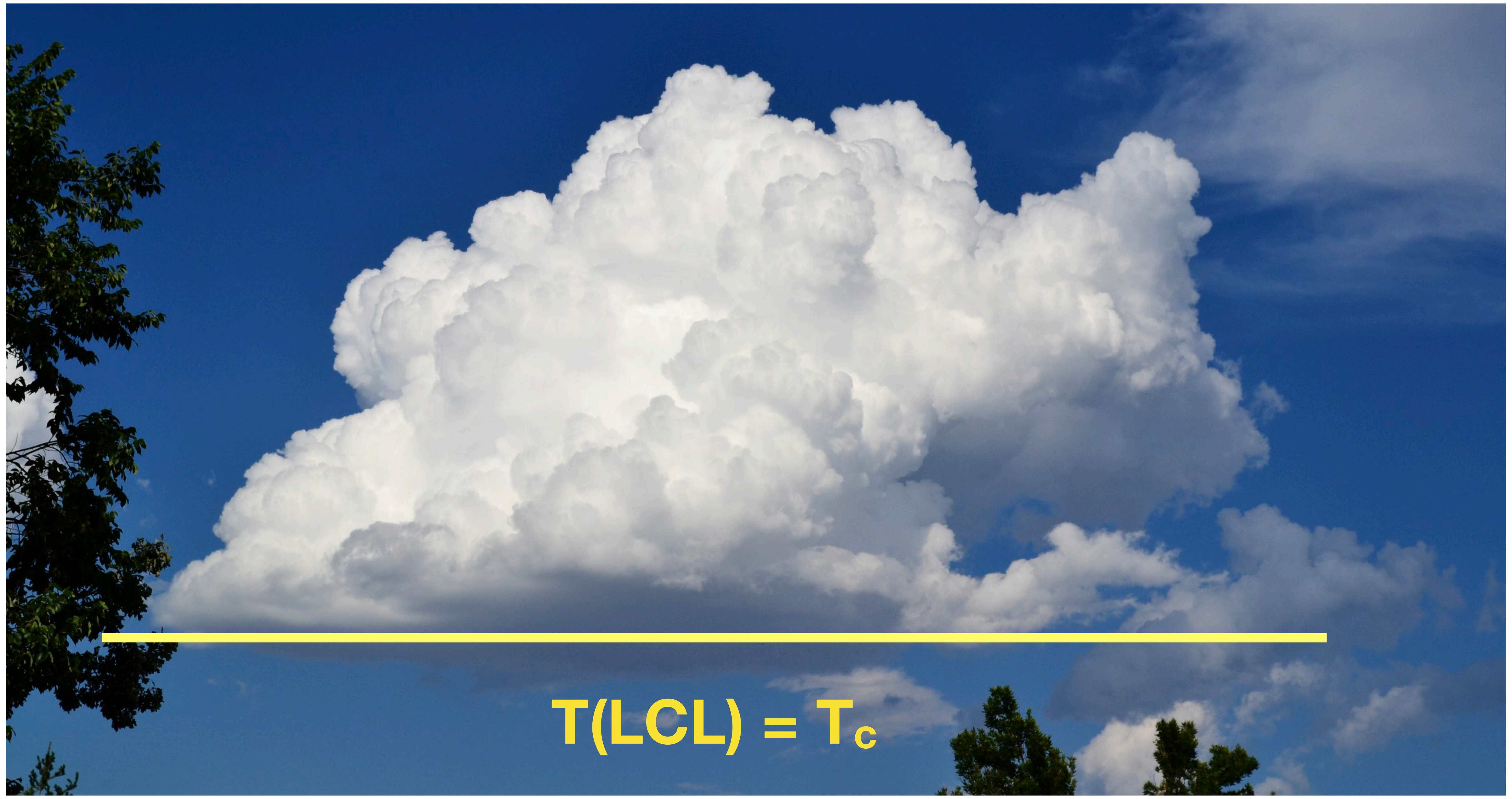
Empirical formula for T_c

T in K, and e in hPa

$$T_c \simeq \frac{2840}{3.5 \ln T - \ln e - 4.8} + 55$$

So many temperatures !

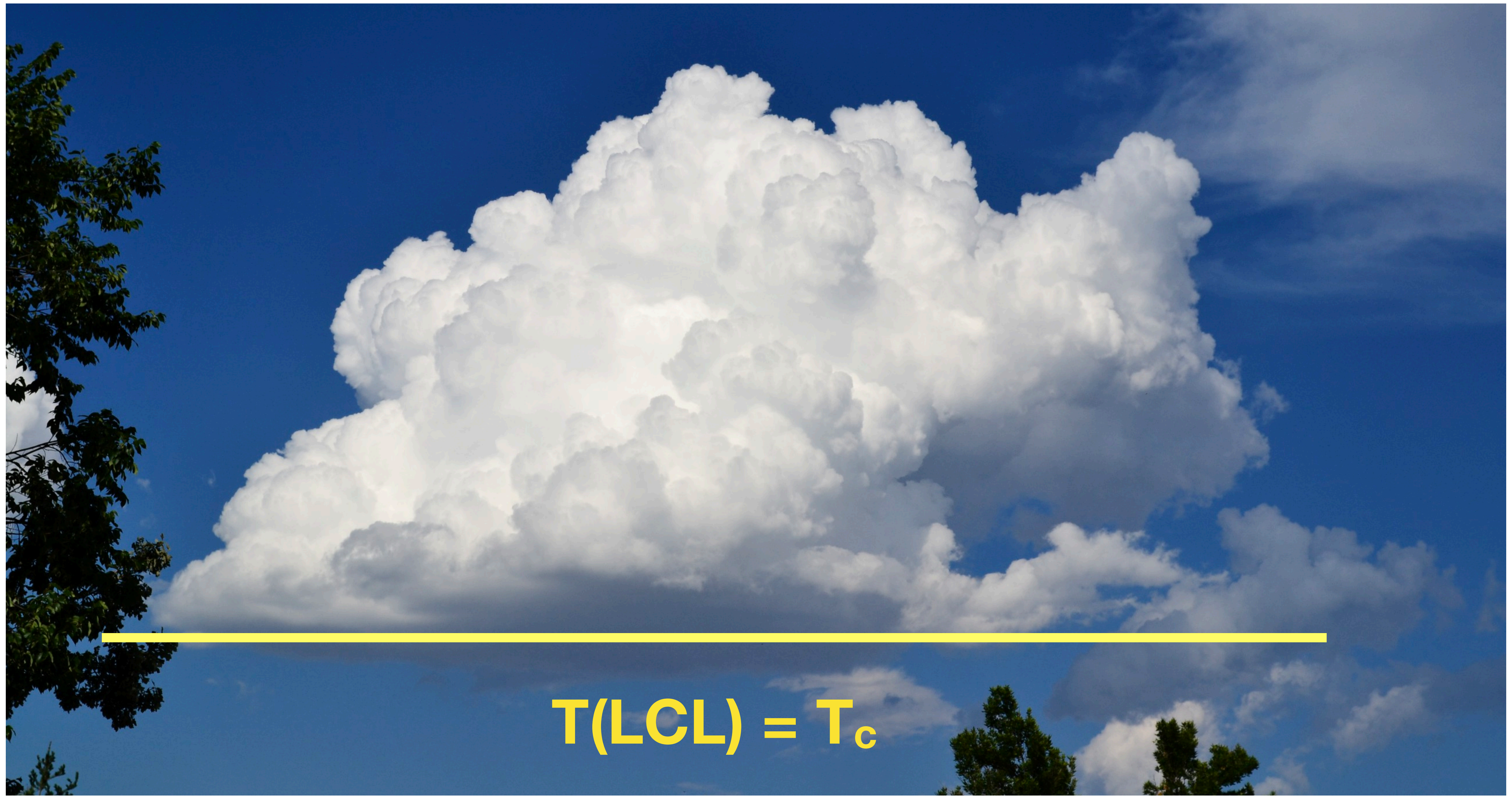
So what happens to parcels once they start condensing into a cloud?



Today

Discuss the moist adiabatic process

Introduce the equivalent potential temperature, the moist entropy and the moist static energy



Supplementary Reading:
Petty 7.8
Wallace & Hobbs 3.5.5

Conservation of water vapor

Once we reach the LCL, we need to take into account changes of phase of water to understand the evolution of our parcel

Heating now becomes important in the thermodynamic equation

$$\frac{Dq_v}{Dt} = S_q$$

$$S_q = e - c + s - d + \mathscr{F}_q / L_v$$

e = evaporation
c = condensation
s = sublimation
d = deposition

$\mathscr{F}_q$ Turbulent flux of latent heat

Conservation of water vapor

$$\frac{Dq_v}{Dt} = S_q$$

$$S_q = \boxed{e} - c + s - d + \boxed{\mathscr{F}_q}/L_v$$

Includes only evaporation that happens within the parcel

Includes evaporation that occurs as a result of turbulent mixing with a surface of water

Assume that heating is mostly from condensation

Need to go back to 1st law to account for condensation

$$c_p dT = \delta q + \alpha dp$$

$$\frac{Dq_v}{Dt} = S_q$$

Latent heat is released during condensation

$$\delta q \simeq L_v(c - e)$$

$$S_q \simeq e - c$$

So our heating is negatively related to changes in moisture

$$\delta q \simeq -L_v dq_v$$

The equivalent potential temperature

Need to go back to 1st law to account for condensation

$$c_p dT = -L_v dq_v + \alpha dp$$

$$\frac{Dq_v}{Dt} = S_q$$

Can be written as

$$c_p T d \ln \theta = -L_v dq_v$$

$$S_q = e - c$$

Which can be solved to obtain

$$\theta_e \simeq \theta \exp\left(\frac{L_v q_v}{c_p T}\right)$$

The equivalent potential temperature

The temperature a parcel would have if it condensed all its water vapor and was brought to the surface adiabatically

The equivalent potential temperature

While θ is not conserved once a cloud begins to develop, θ_e **is** conserved.

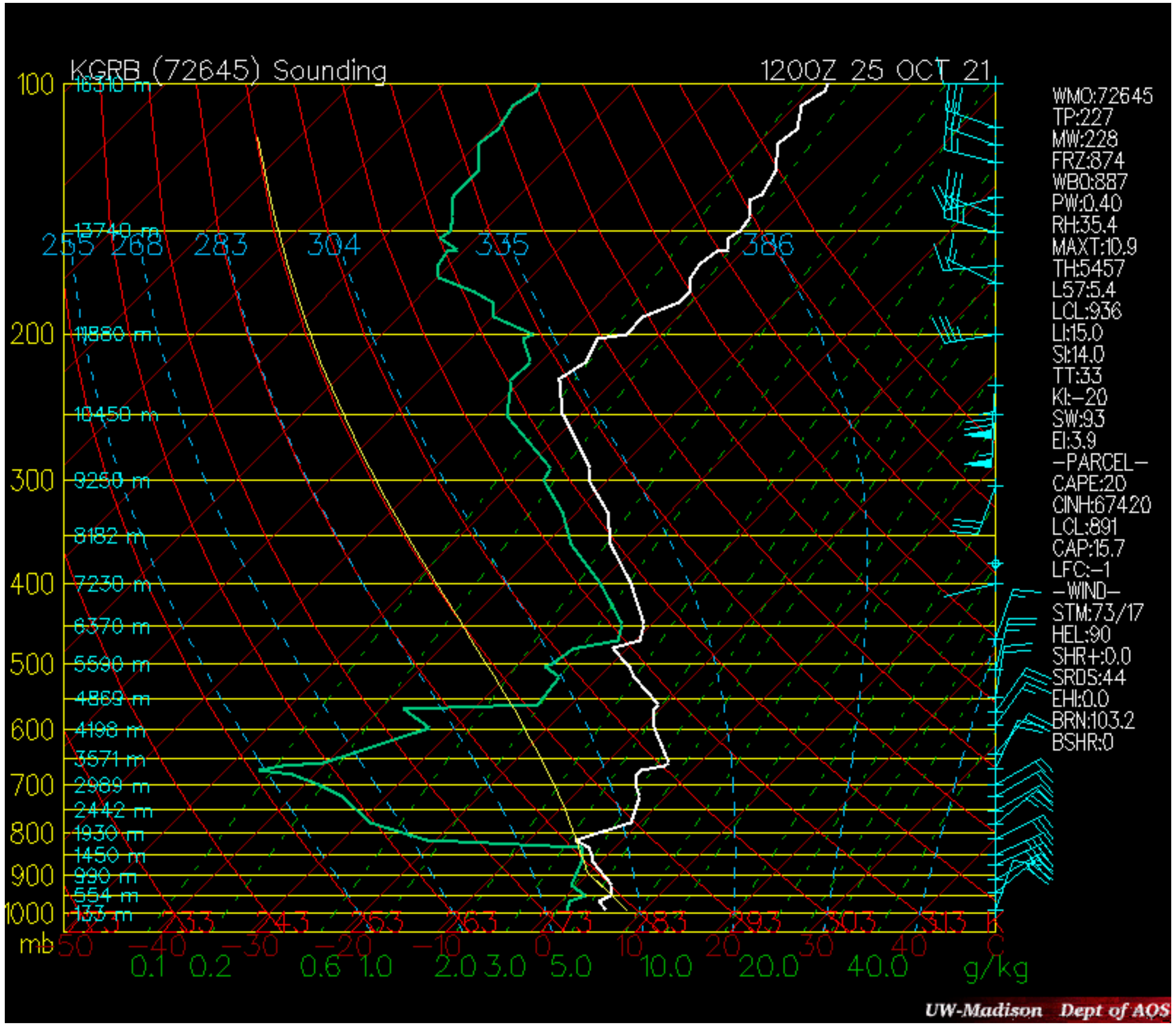
In fact, θ_e is conserved even if no condensation is occurring. Thus, it is a very useful variable when trying to understand our atmosphere

Moist adiabatic process

A moist adiabatic process is one in where you rise adiabatically and there is condensation/evaporation in the parcel. You will also hear the terms saturated adiabatic and pseudoadiabatic in association with this process.

The process is **reversible** is the water stays in the parcel. It is **irreversible** if it falls out as rain.

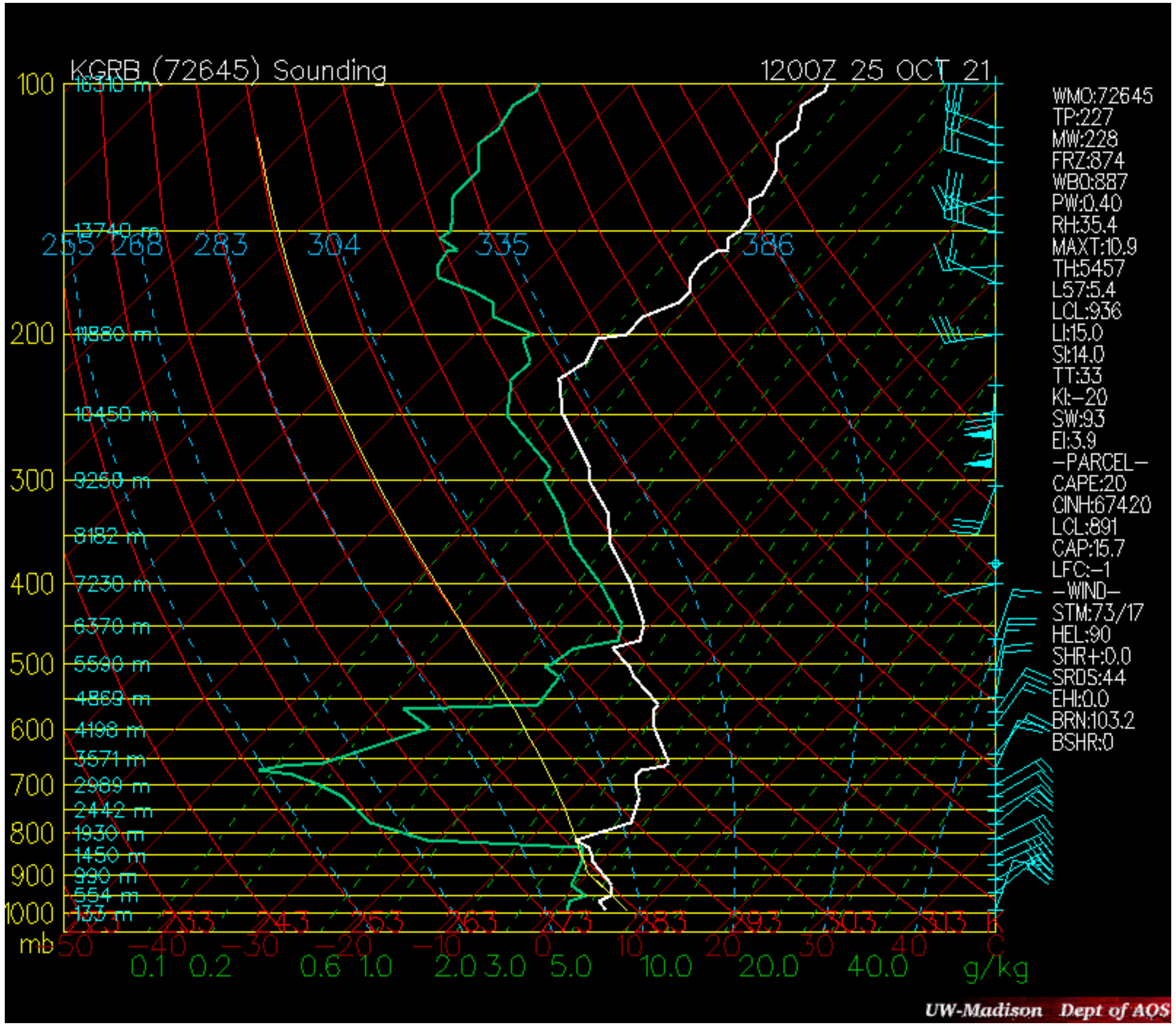
Moist adiabatic processes in a Skew-T



The **dashed blue lines** are moist adiabats, lines of constant θ_e.

A cloudy parcel would follow this line if it was forced to rise.

Skew-T a week



Download 2 soundings, one from a humid tropical location and one from a cold midlatitude or polar region.

1. Discuss how the temperature of a parcel that rises moist adiabatically would change if it rose.

2. Which one would cool off faster and why?