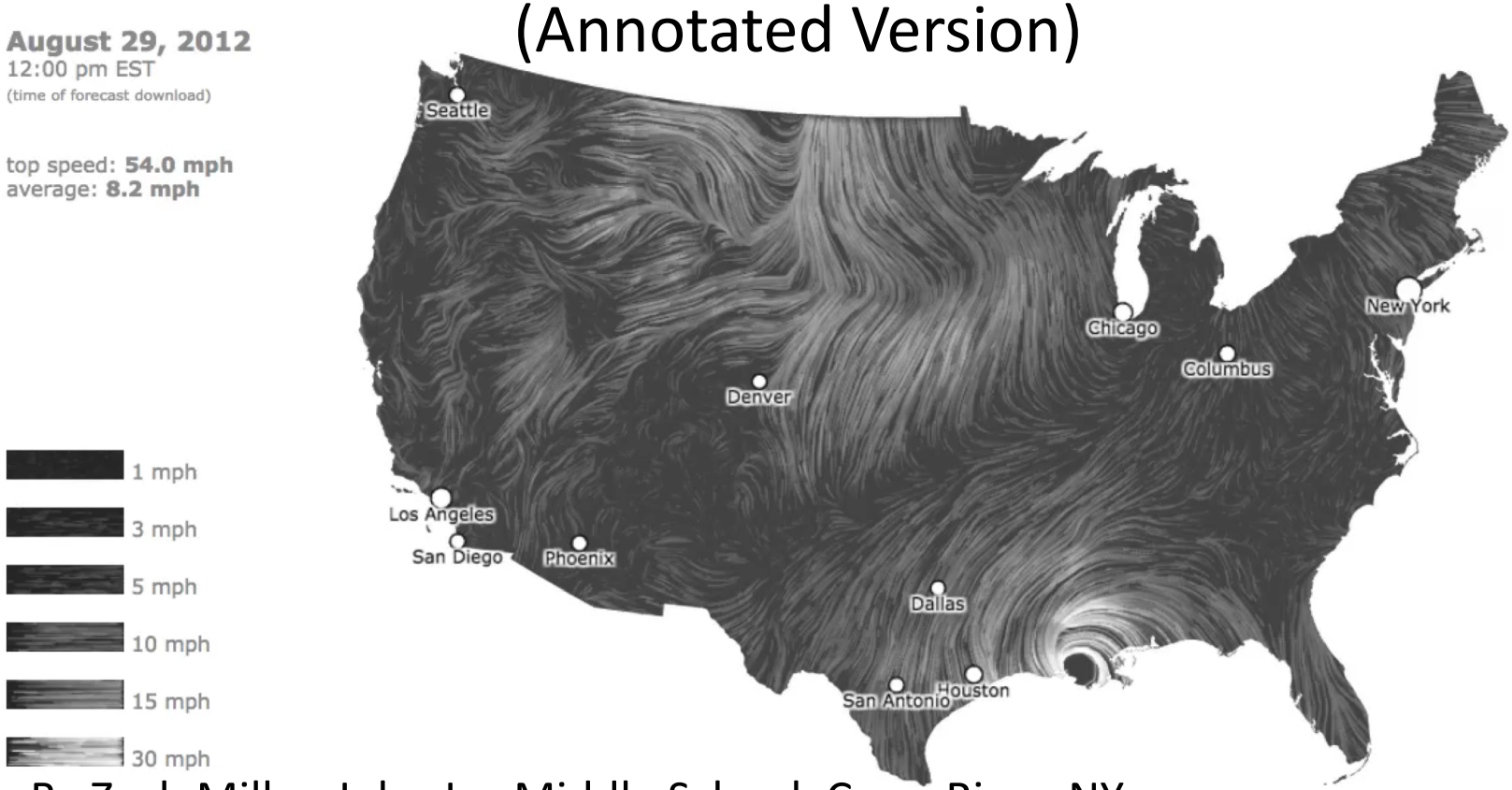
Planetary Wind & Moisture Belts in the Troposphere (Annotated Version)



- By Zach Miller, John Jay Middle School, Cross River, NY.
- Above wind vector animation from http://hint.fm/wind/. (Hurricane Isaac is visible in this animation making landfall on the Louisiana coastline on August 29, 2012.)
- All background images in the following presentation are adapted from New York State Earth Science Reference Tables (2011 Edition, p. 14).
- Other credits and related wind resources are **HERE**.

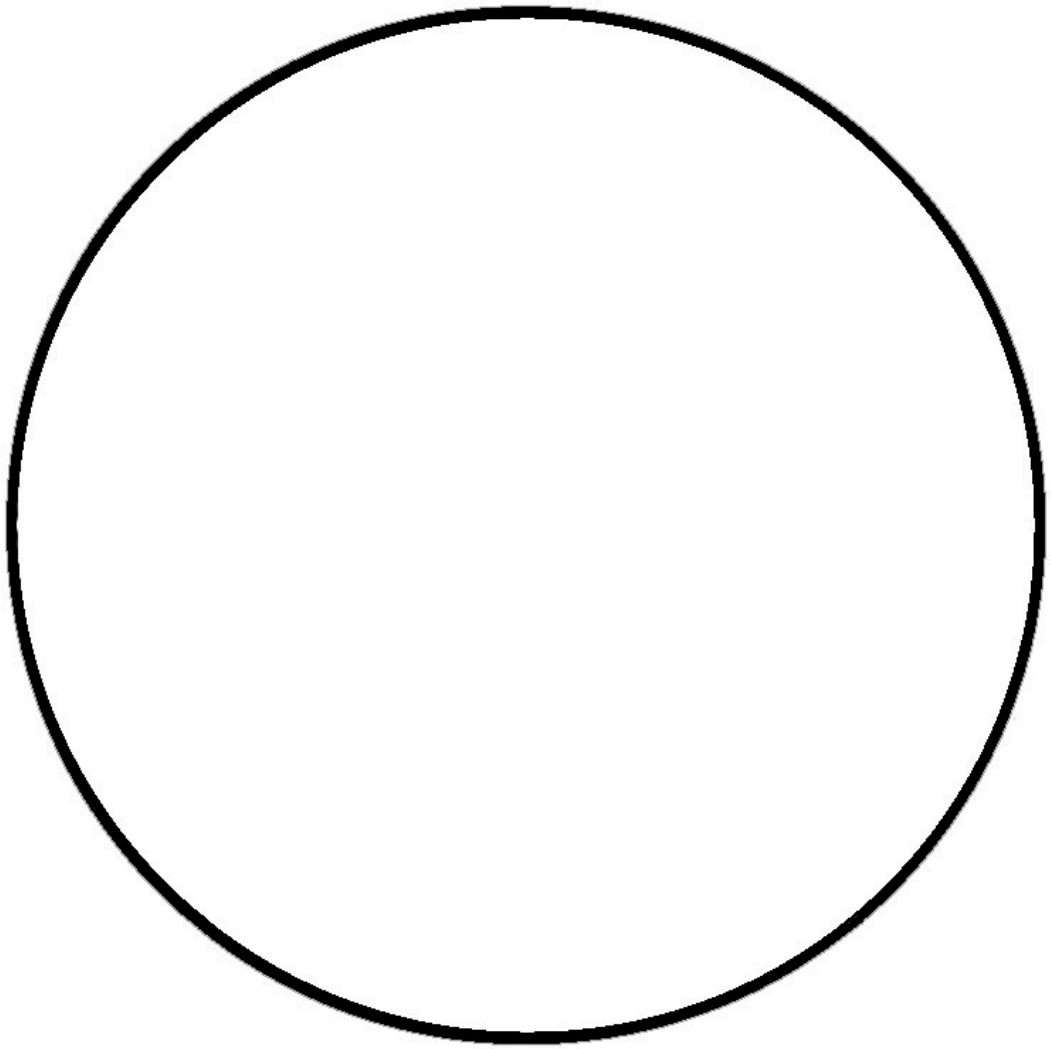
Convection & Moisture Belts: Part 1

What causes air to move?

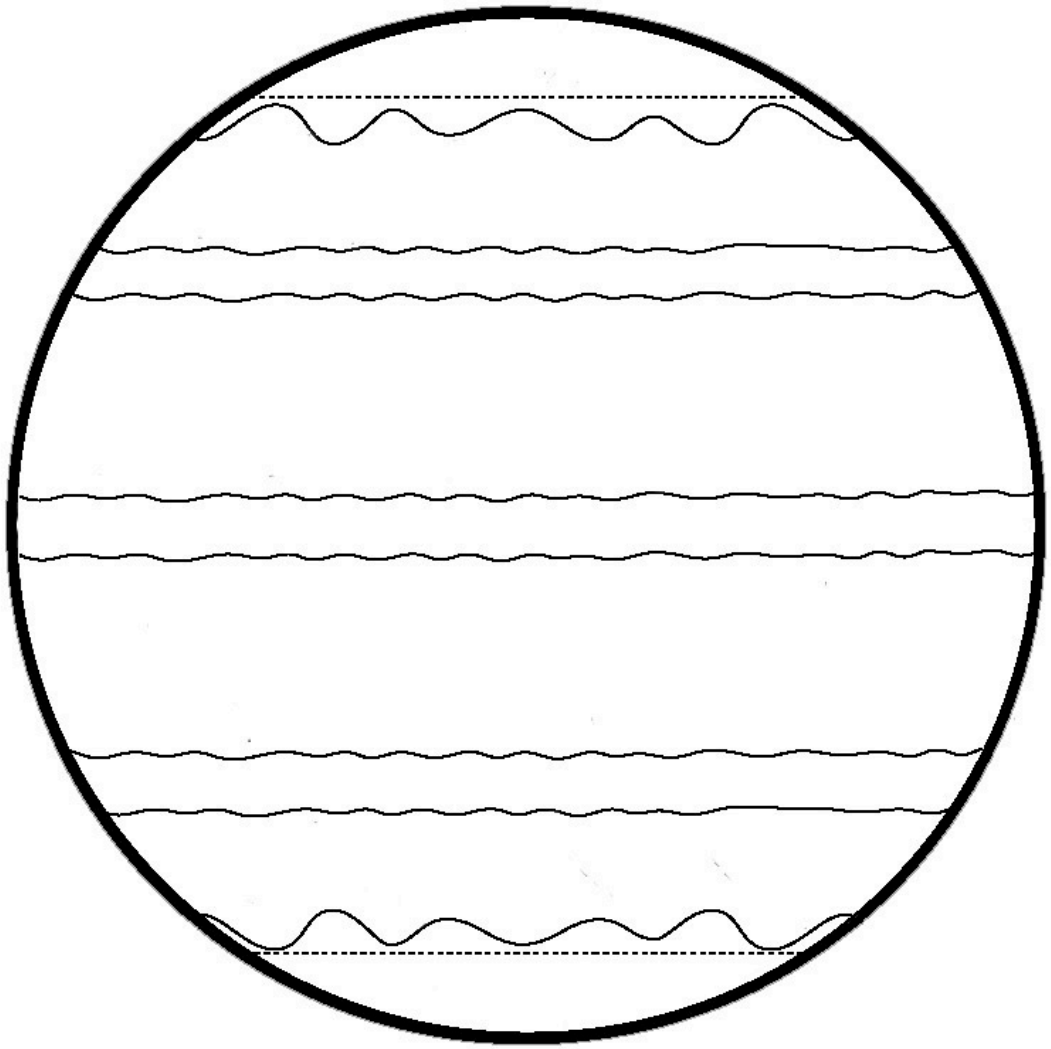
&

How does air movement create moisture belts?

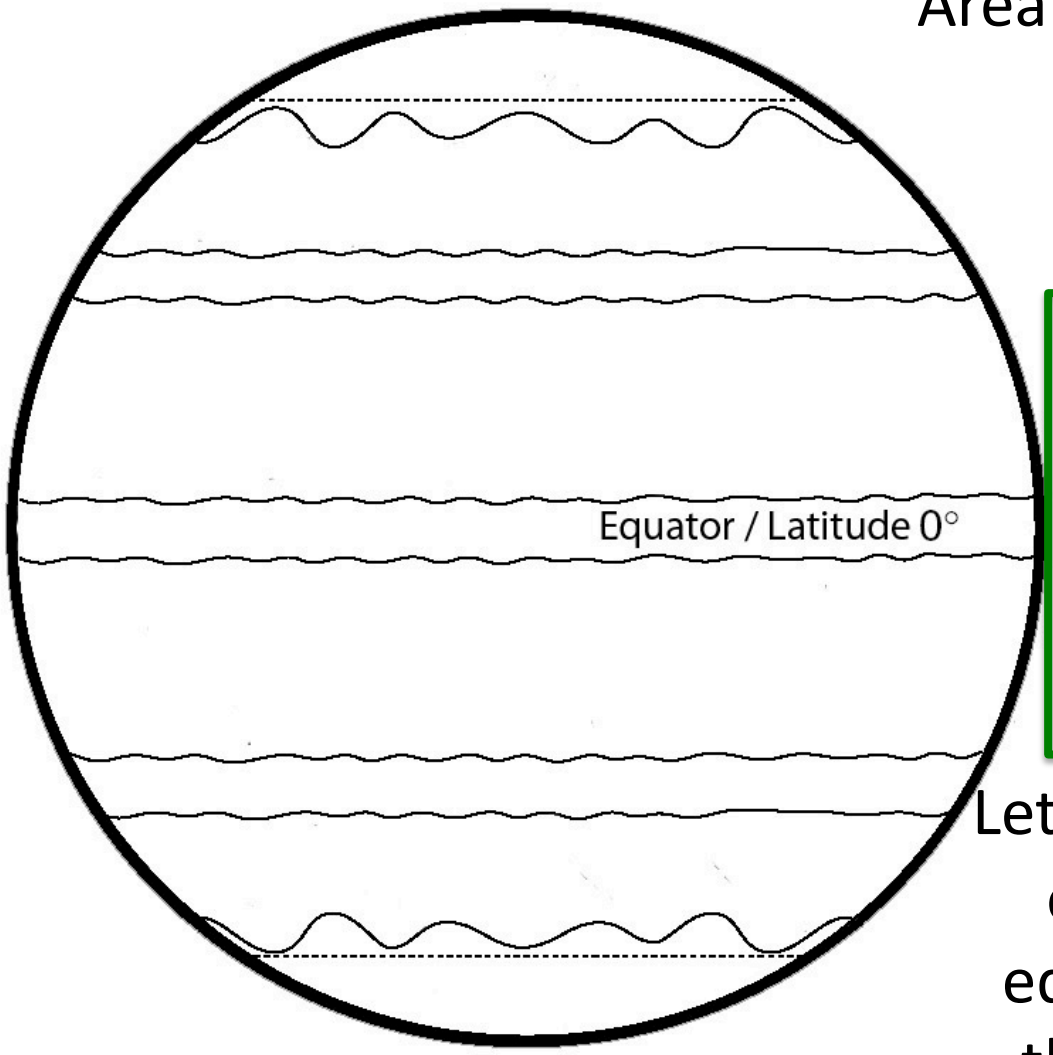
Convection & Moisture Belts



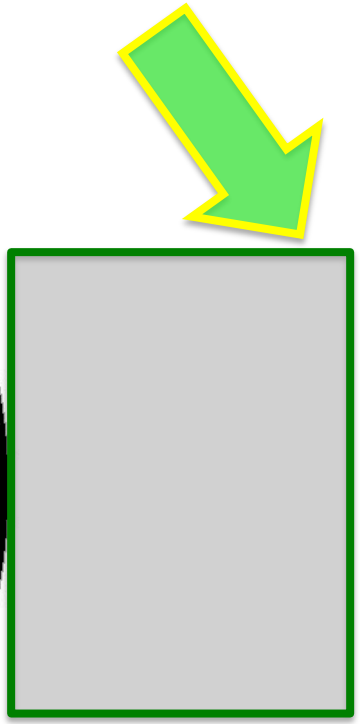
Convection & Moisture Belts



Convection & Moisture Belts



Area of Interest.

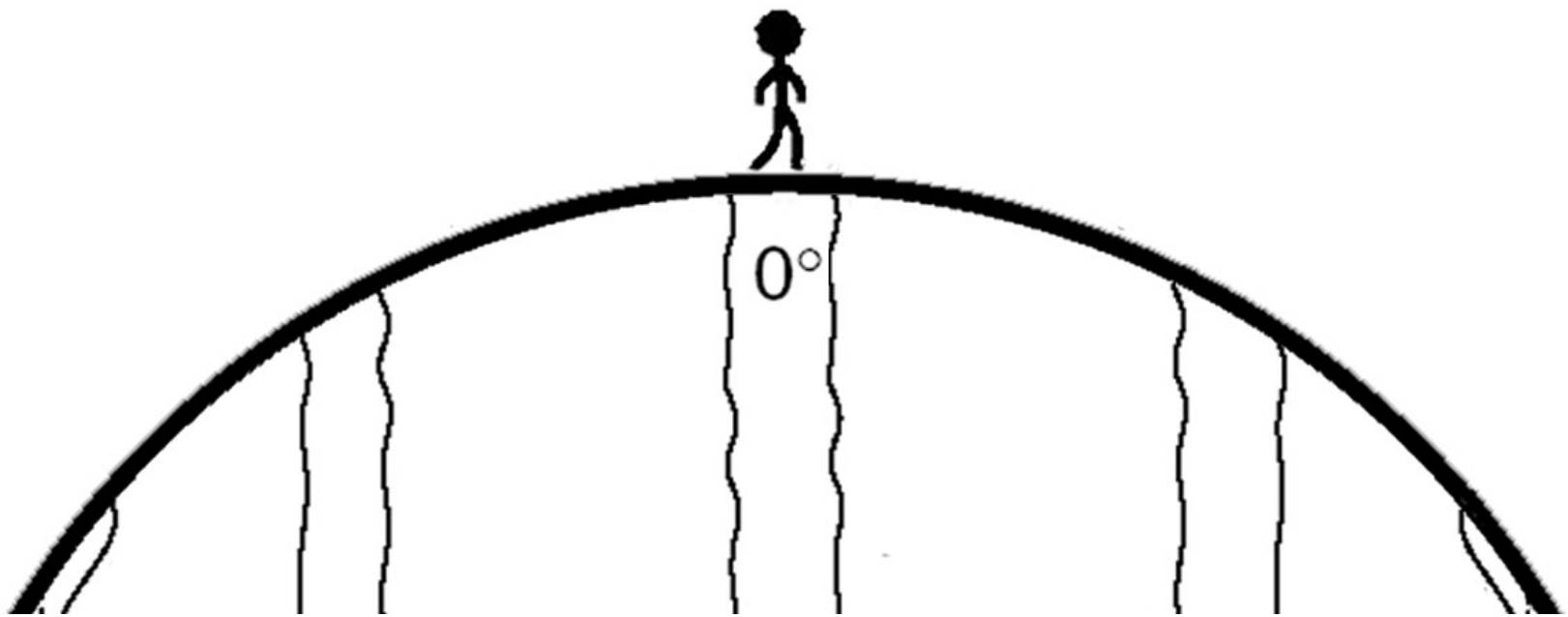


Let us focus on an observer at the equator & rotate the diagram 90° counter-clockwise.

Convection & Moisture Belts

<u>Atmospheric Characteristics at the Equator (0° latitude)</u>:

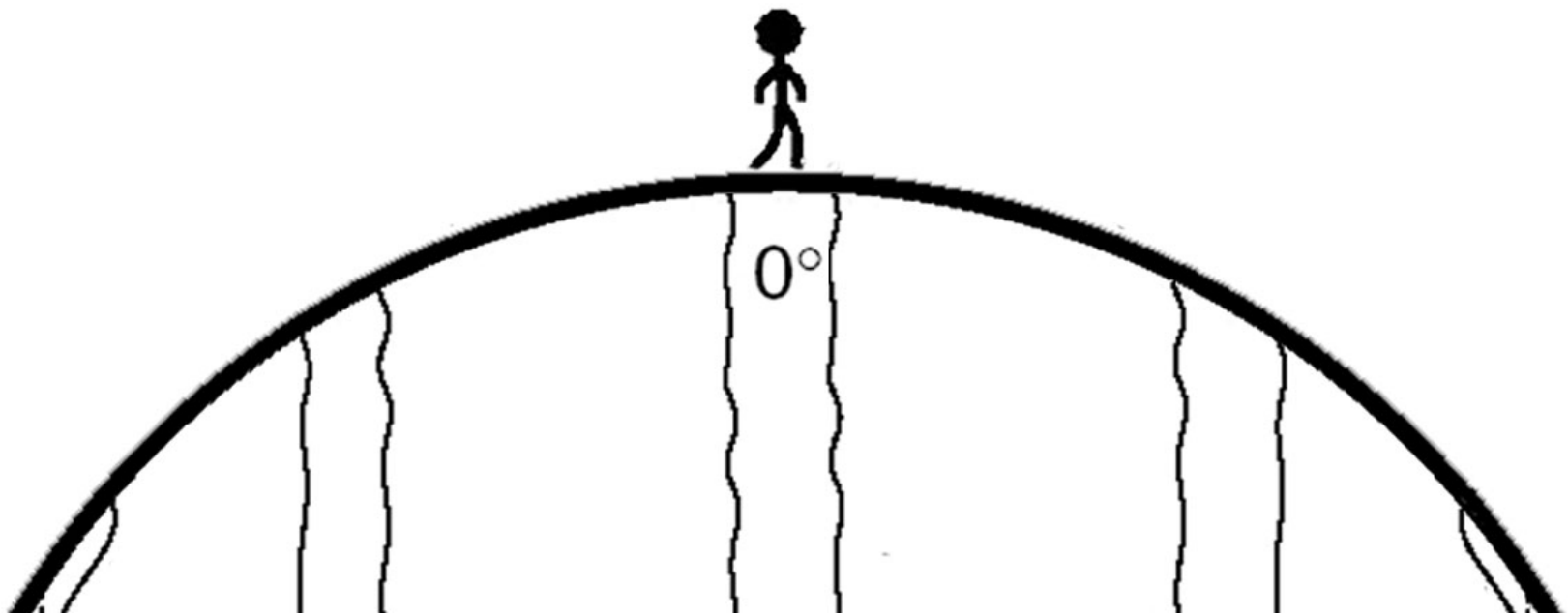
- **Warm air** has high potential evapotranspiration.
- This leads to air masses having **high moisture content** from various sources: surface water (oceans, lakes, streams), soil moisture, and plants.
- Therefore, **maritime tropical ("mT")** often dominates this area.



Convection & Moisture Belts

<u>Behavior of warm moist air at the equator</u>:

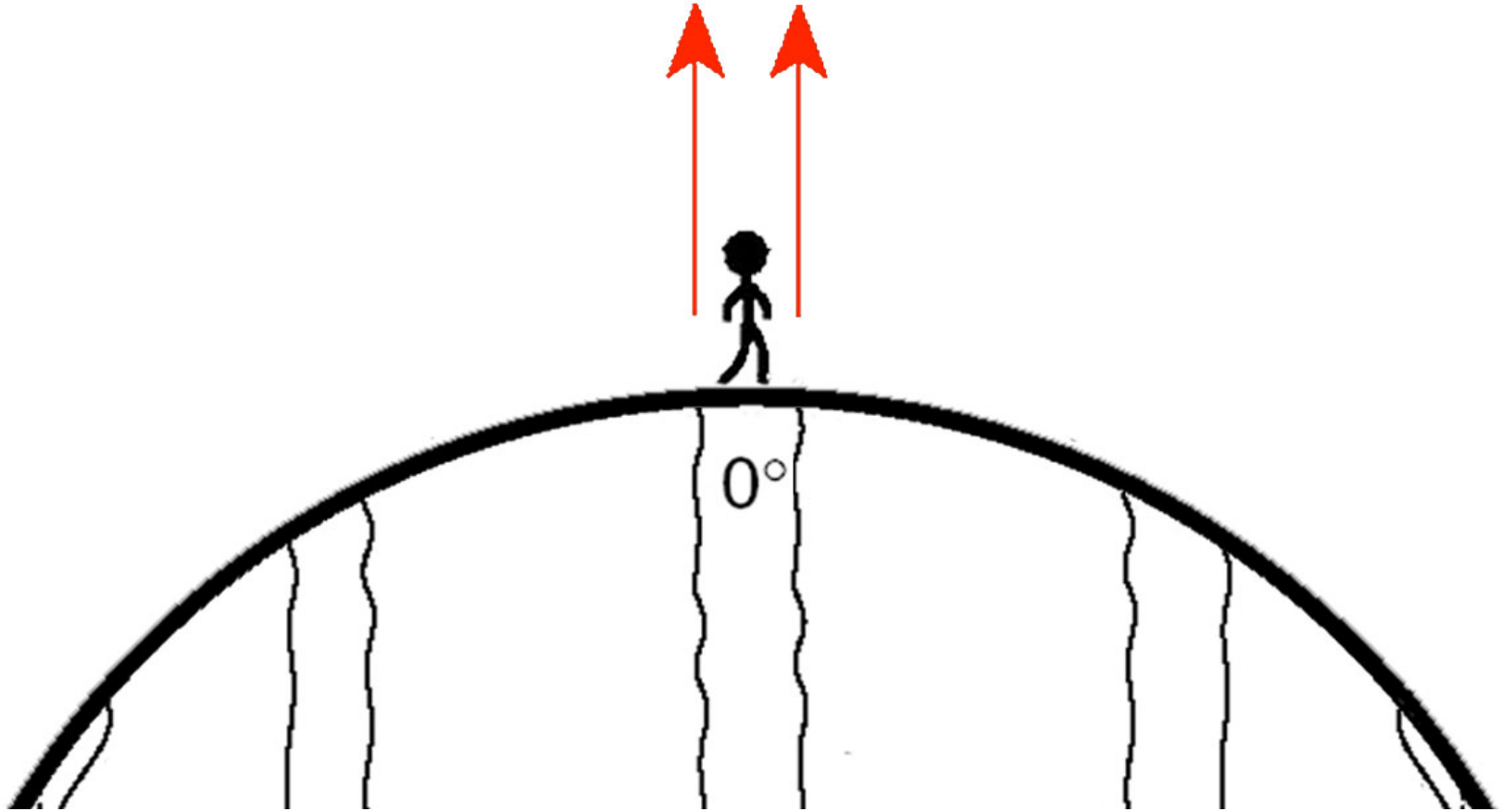
- Warm air is less dense compared to cool air.
- Cold air moves underneath warm air – warm air rises as it's lifted by relatively cold dense air moving in beneath it.



Convection & Moisture Belts

<u>Behavior of warm moist air at the equator</u>:

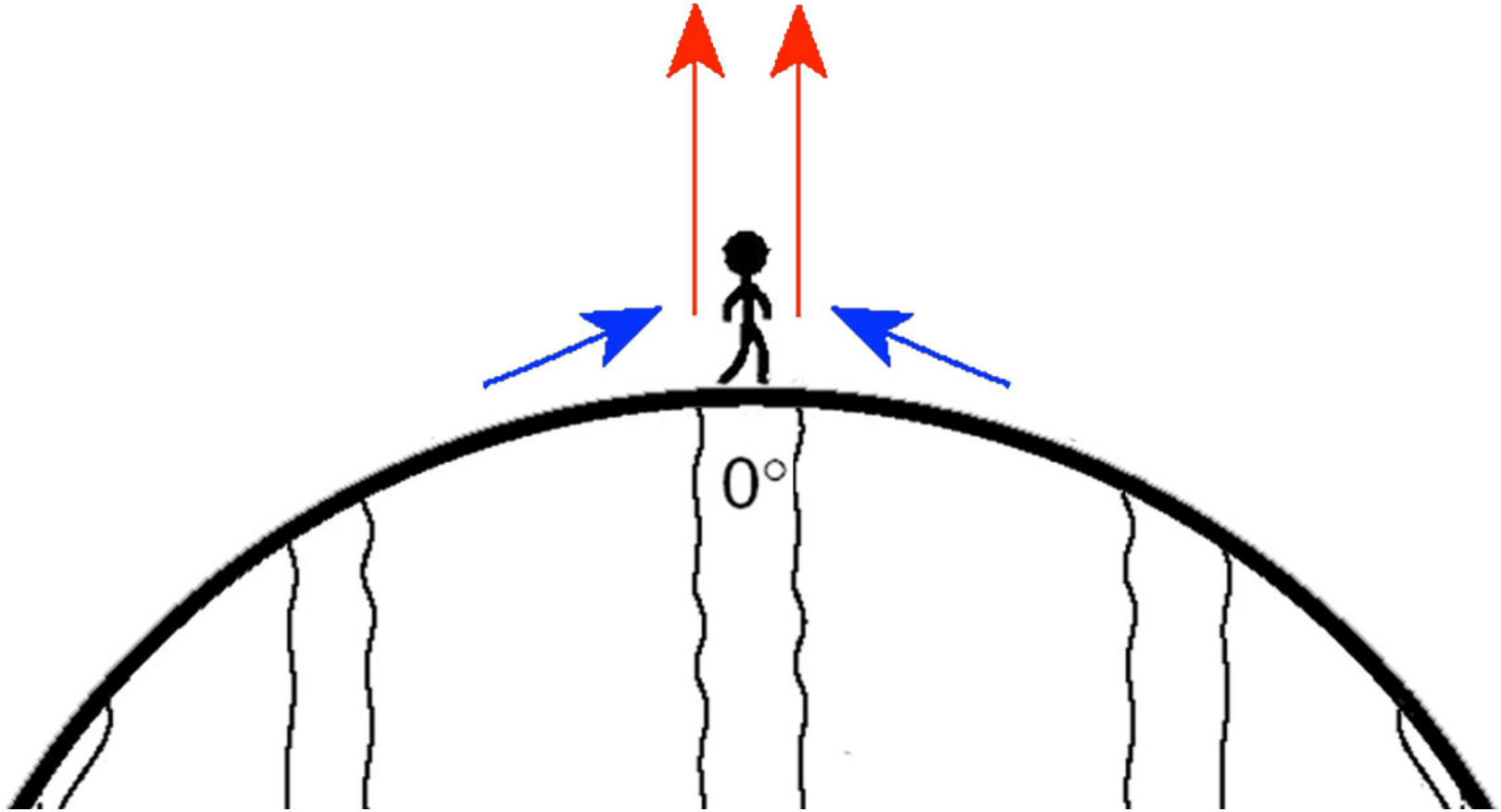
- Warm air is less dense compared to cool air.
- Cold air moves underneath warm air – warm air rises as it's lifted by relatively cold dense air moving in beneath it.



Convection & Moisture Belts

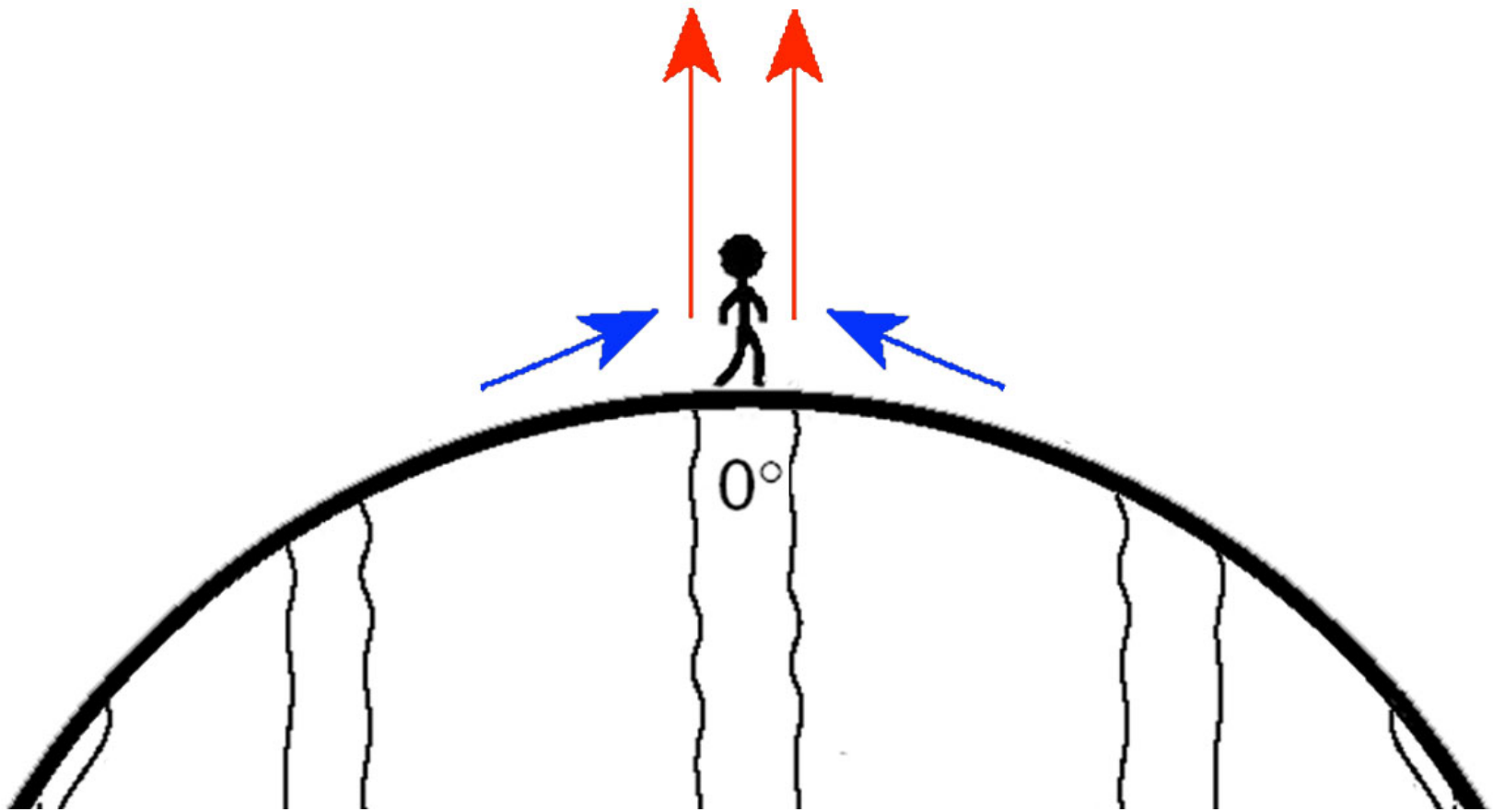
<u>Behavior of warm moist air at the equator</u>:

- Warm air is less dense compared to cool air.
- Cold air moves underneath warm air – warm air rises as it's lifted by relatively cold dense air moving in beneath it.



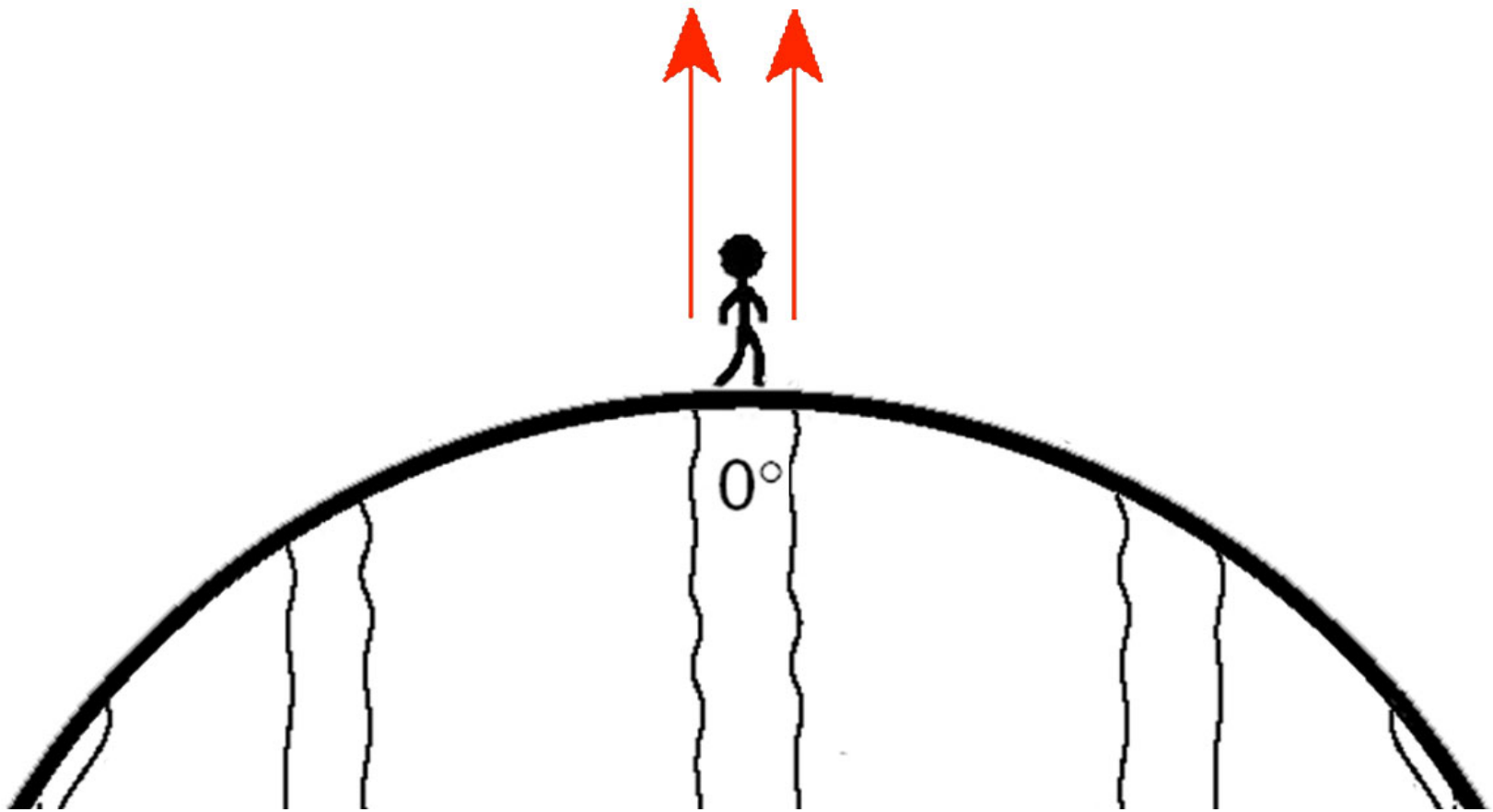
Convection & Moisture Belts

- The model below is simplified, as it lacks gradual changes in air temperature and resulting precipitation patterns.
- Continue for further details…



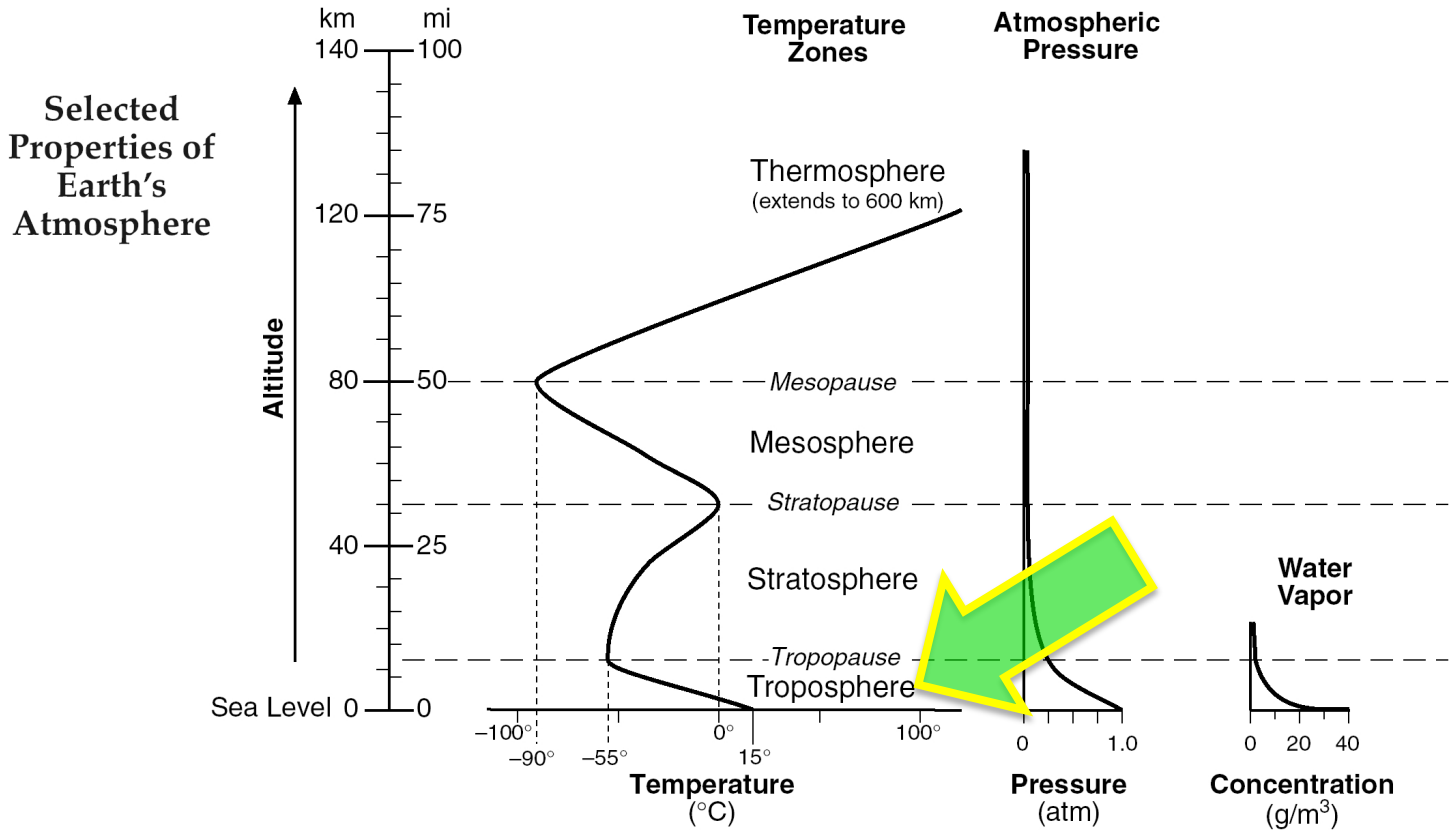
Convection & Moisture Belts

- Let's start by examining the warm moist air rising vertically in the atmosphere.
- What happens to the mT air mass as it rises?



Convection & Moisture Belts

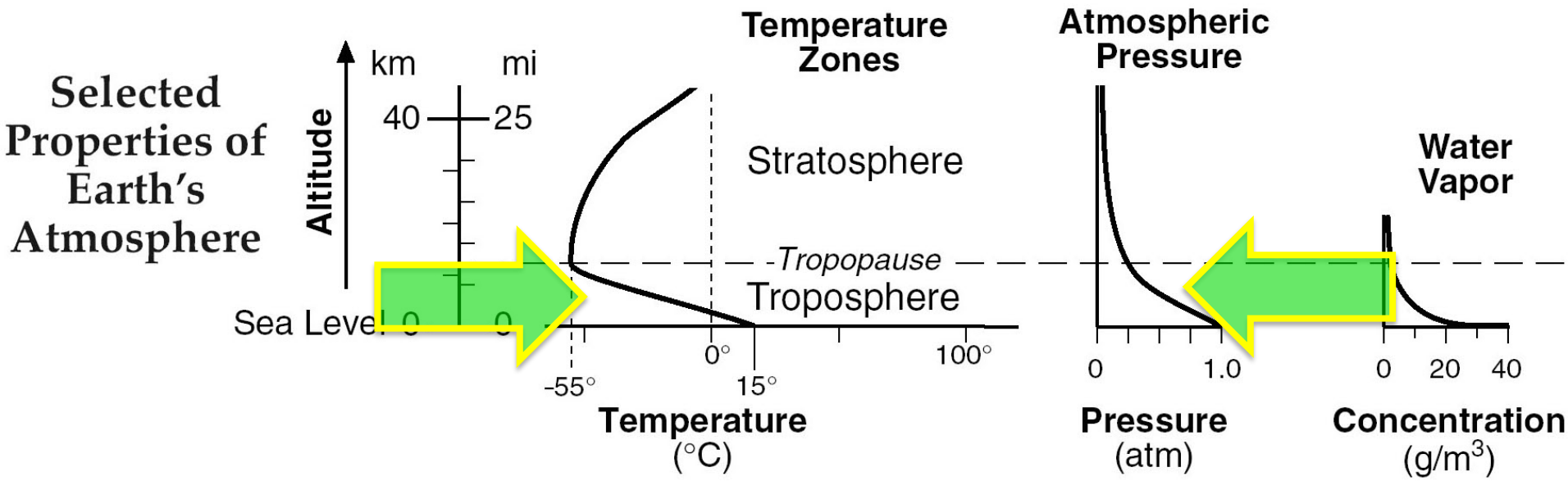
- Refer to your Earth Science Reference Tables atmosphere layers diagram on p. 14 (see diagram below).
- Find the term “troposphere”.



Convection & Moisture Belts

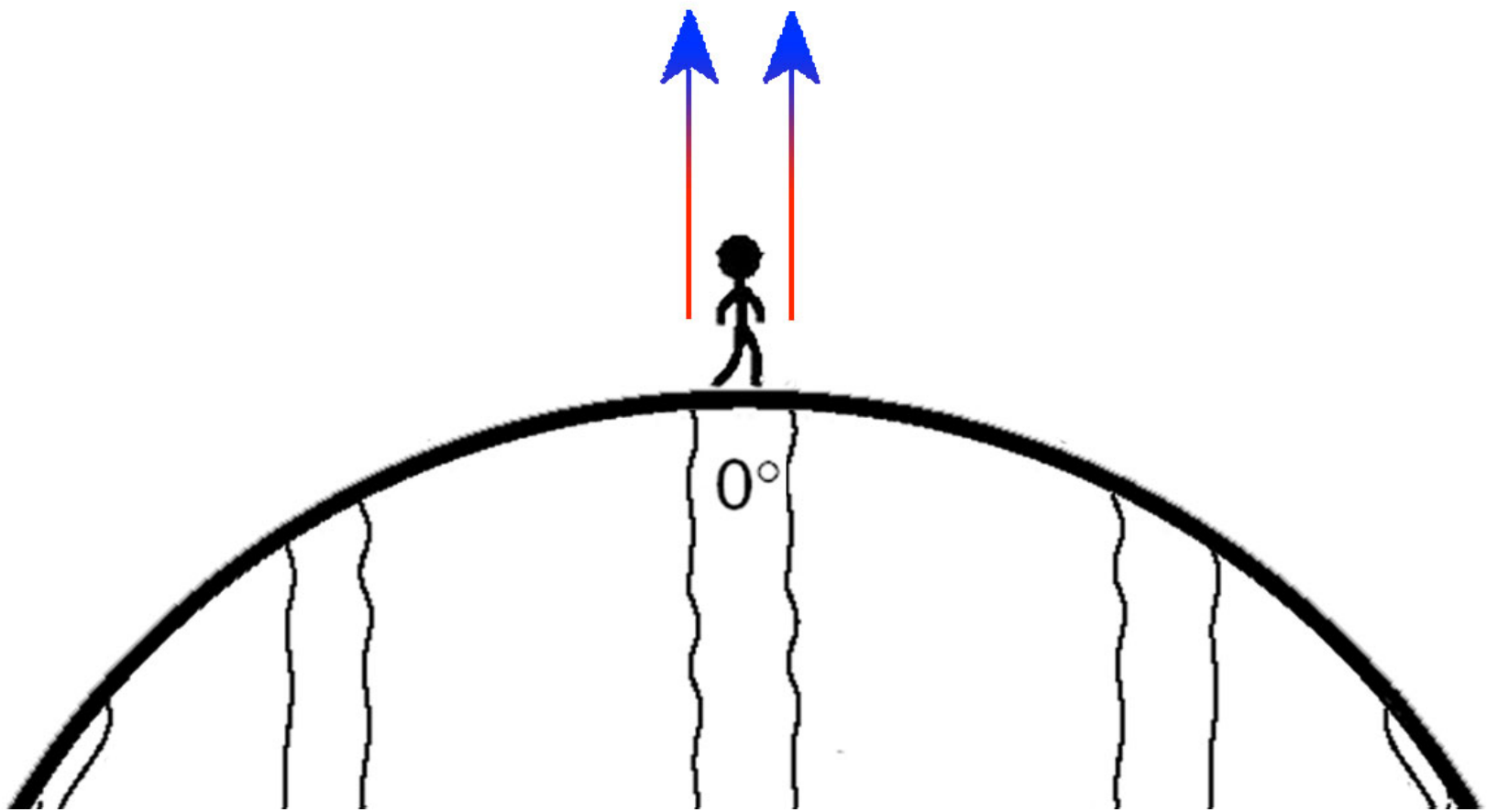
1. Air pressure decreases as the parcel (area) of warm moist (mT) air rises through the atmosphere.
2. Air expands as air pressure decreases.
3. Air cools as it expands.

We will update our model to reflect this process.



Convection & Moisture Belts

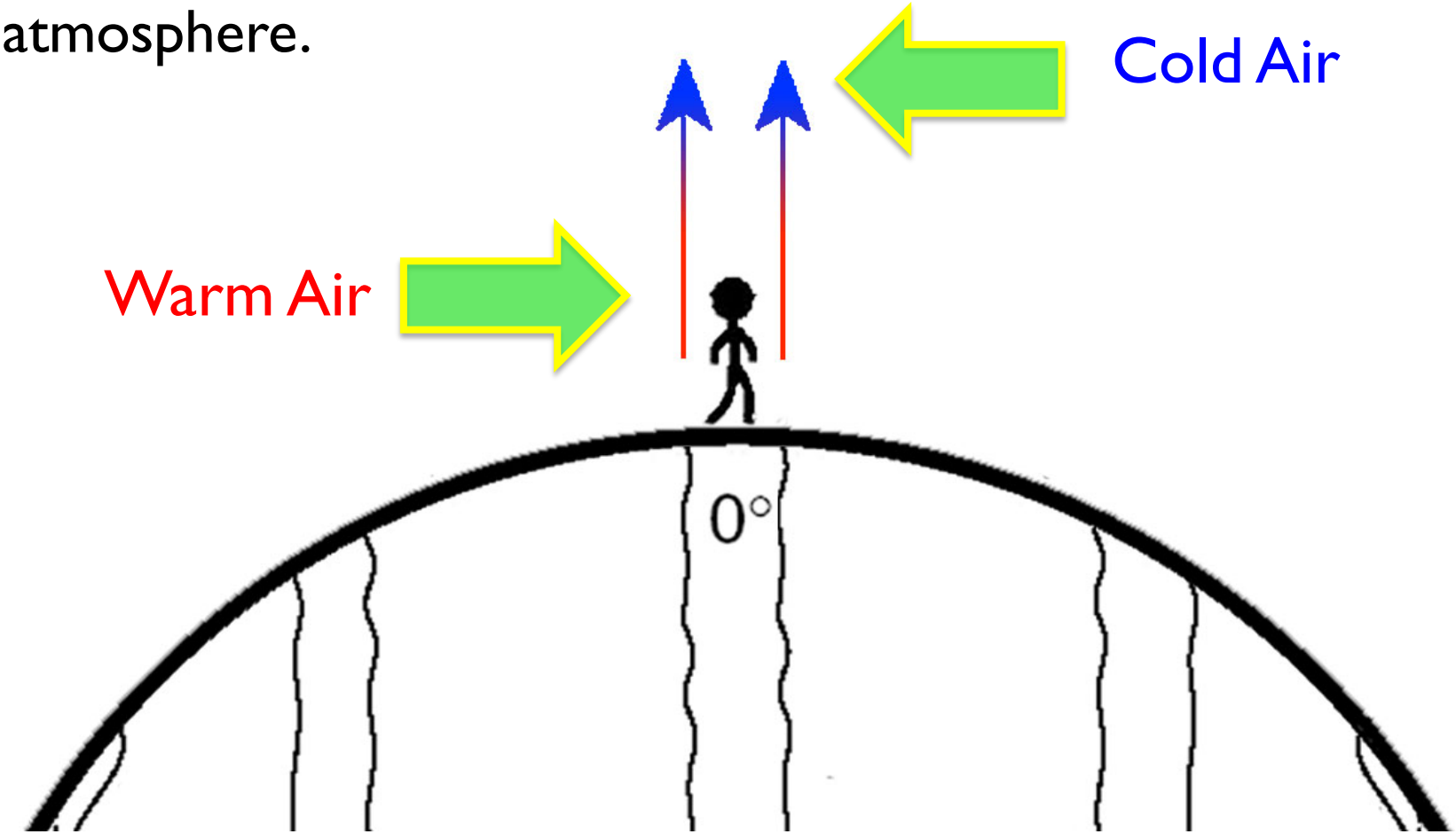
- The diagram below will now reflect this gradual decrease in temperature as altitude increases.



Convection & Moisture Belts

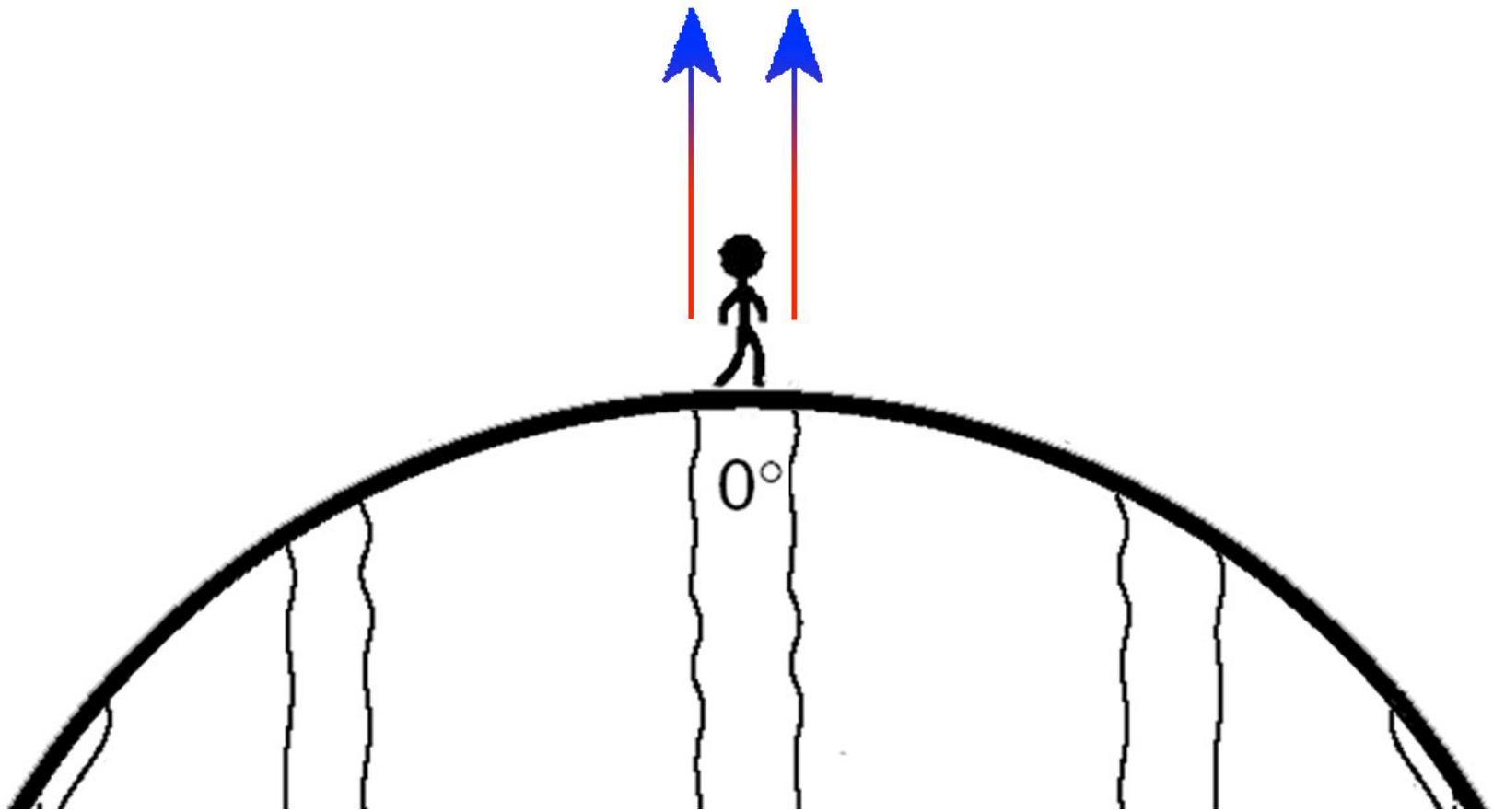
<u>To review</u>:

- Warm moist (mT) air rises due to colder denser air moving underneath it.
- The warm air cools as it rises to higher altitudes in the atmosphere.



Convection & Moisture Belts

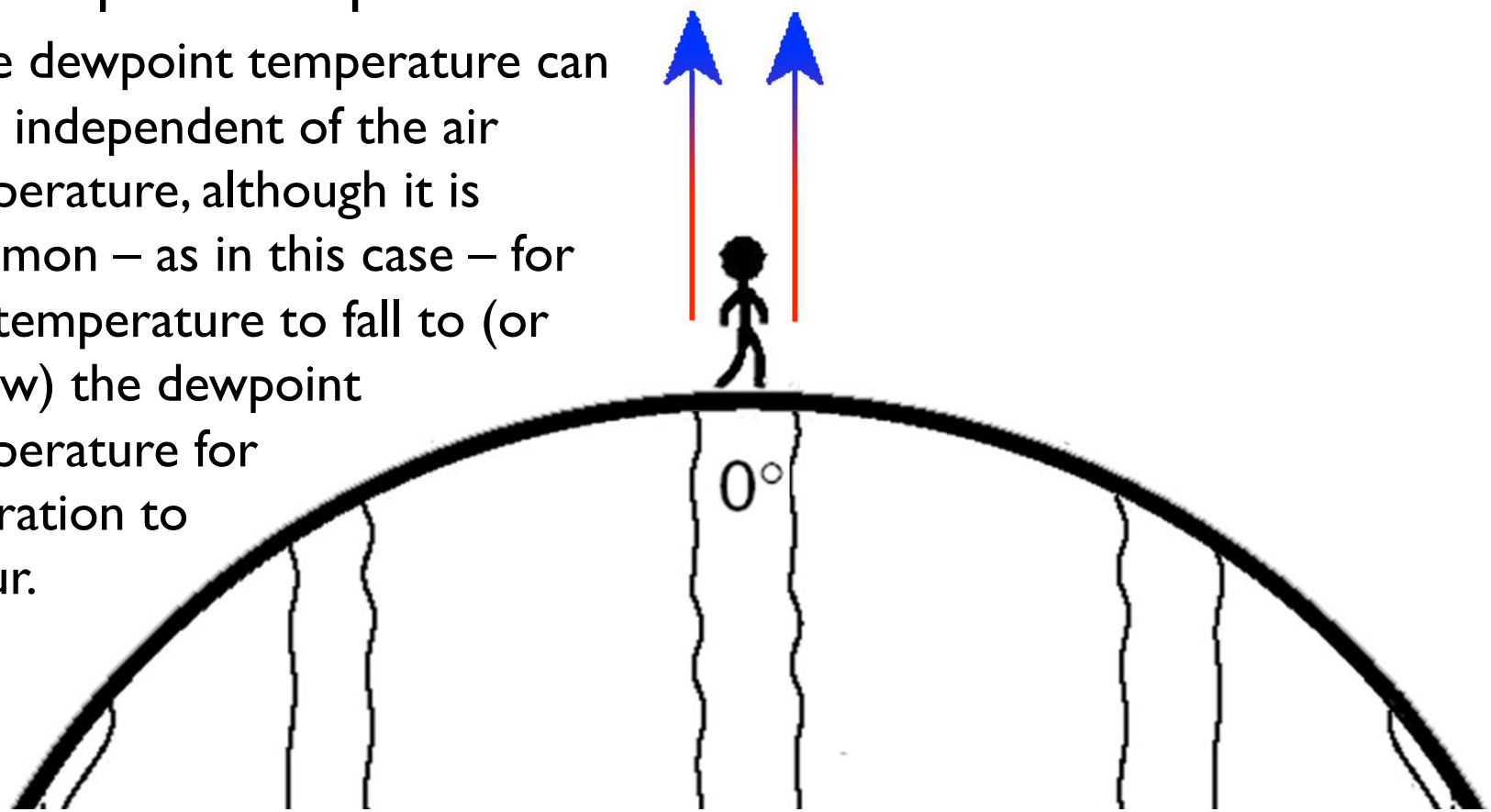
- How does the cooling of warm moist air relate to precipitation?



Convection & Moisture Belts

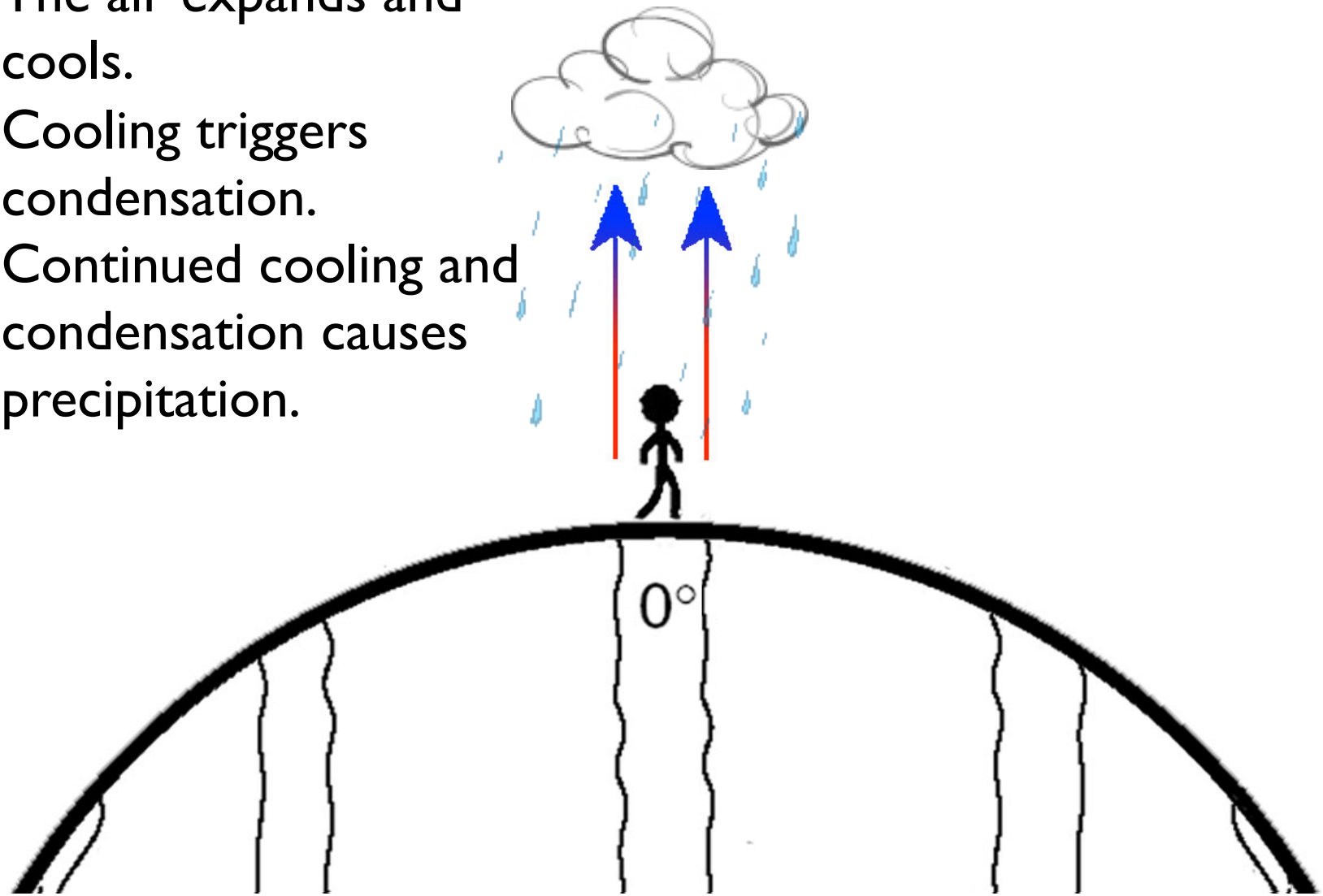
- Air must be saturated with water vapor for precipitation to occur.
- Air is often saturated by water vapor due to the air temperature falling to (or below) the dewpoint temperature.*

*The dewpoint temperature can vary independent of the air temperature, although it is common – as in this case – for the temperature to fall to (or below) the dewpoint temperature for saturation to occur.



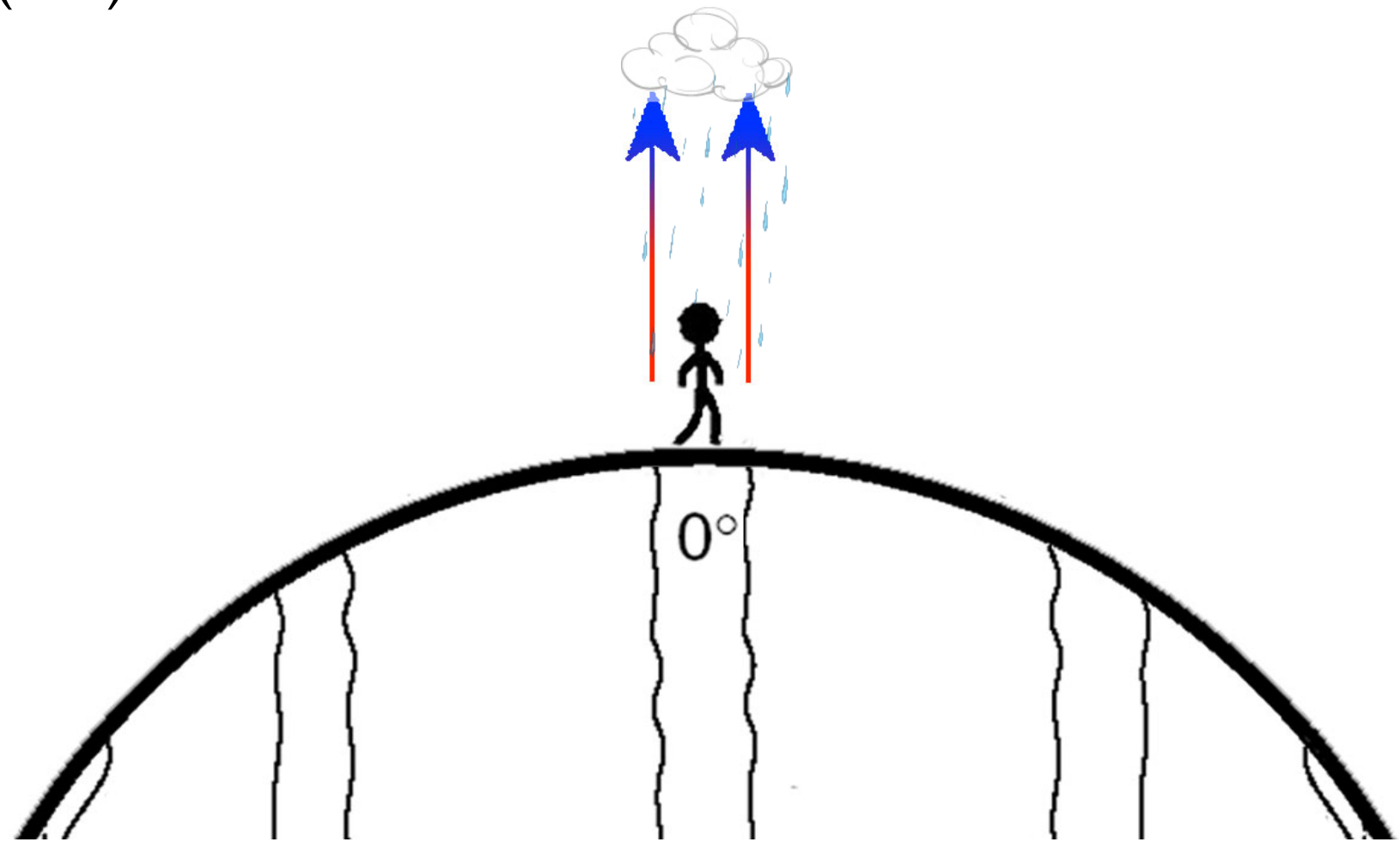
Convection & Moisture Belts

1. Warm moist air rises.
2. The air expands and cools.
3. Cooling triggers condensation.
4. Continued cooling and condensation causes precipitation.



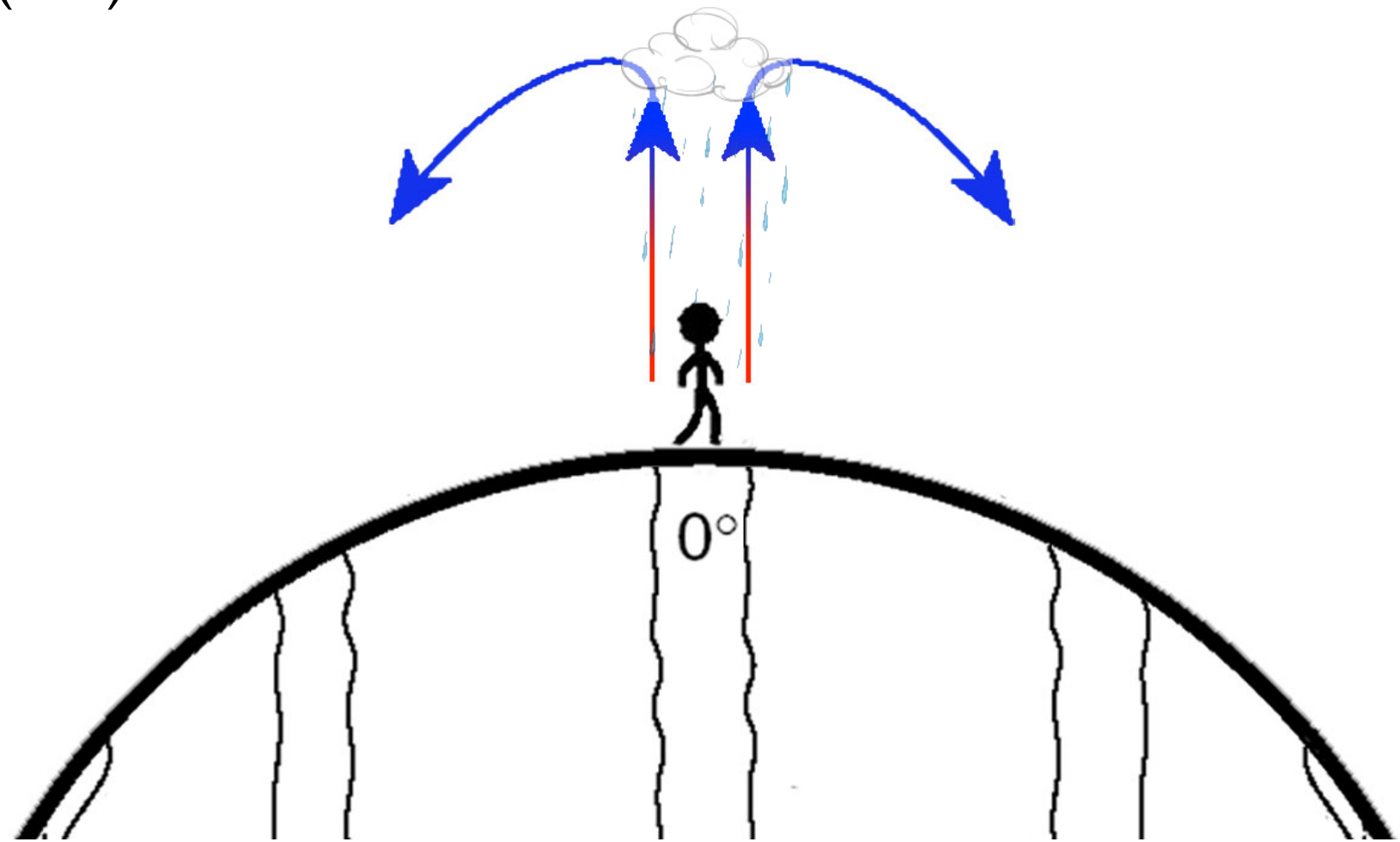
Convection & Moisture Belts

- The cold dense air at higher altitudes has only one "escape route" – to diverge (spread out) and descend (sink) back toward earth's surface.



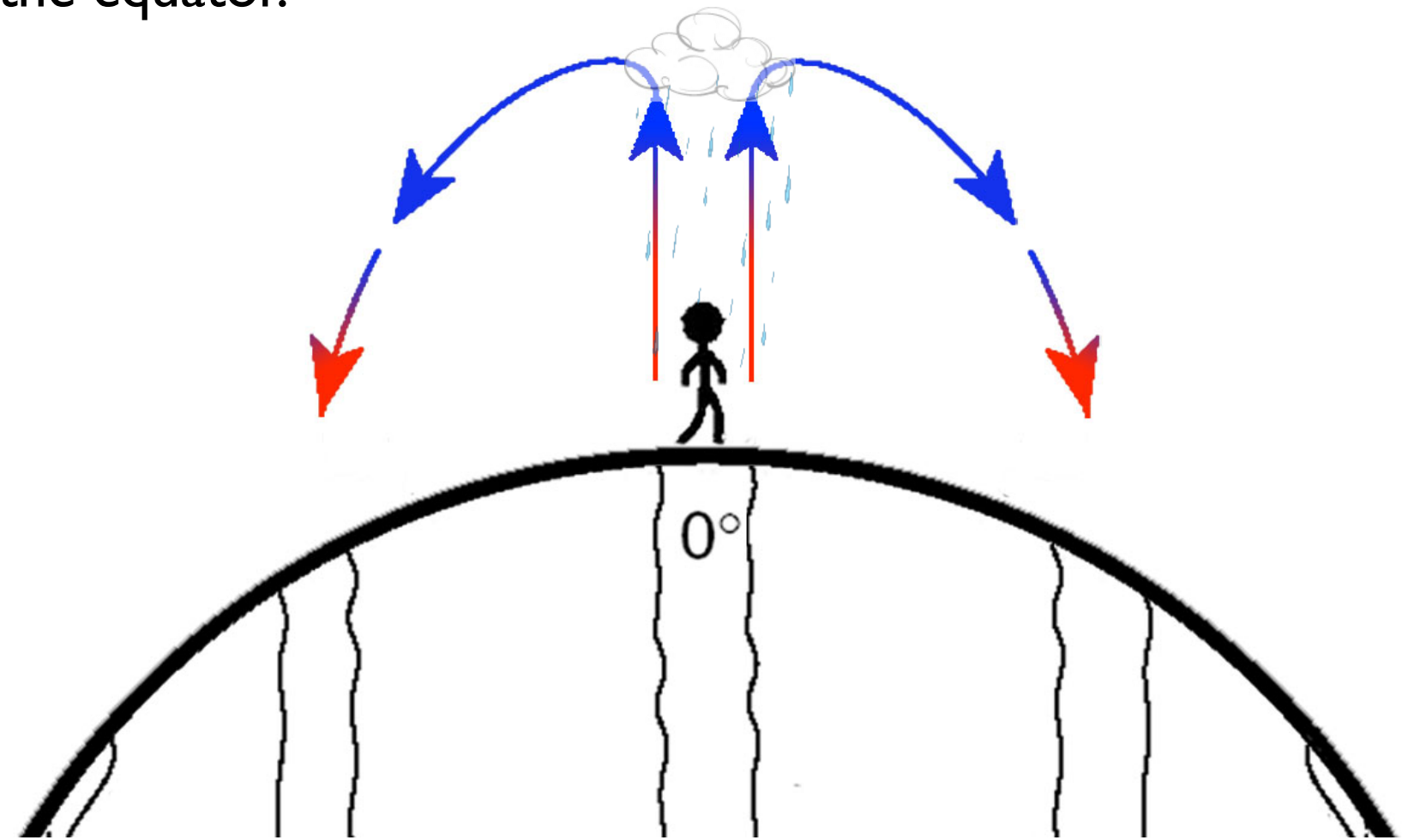
Convection & Moisture Belts

- The cold dense air at higher altitudes has only one "escape route" – to diverge (spread out) and descend (sink) back toward earth's surface.



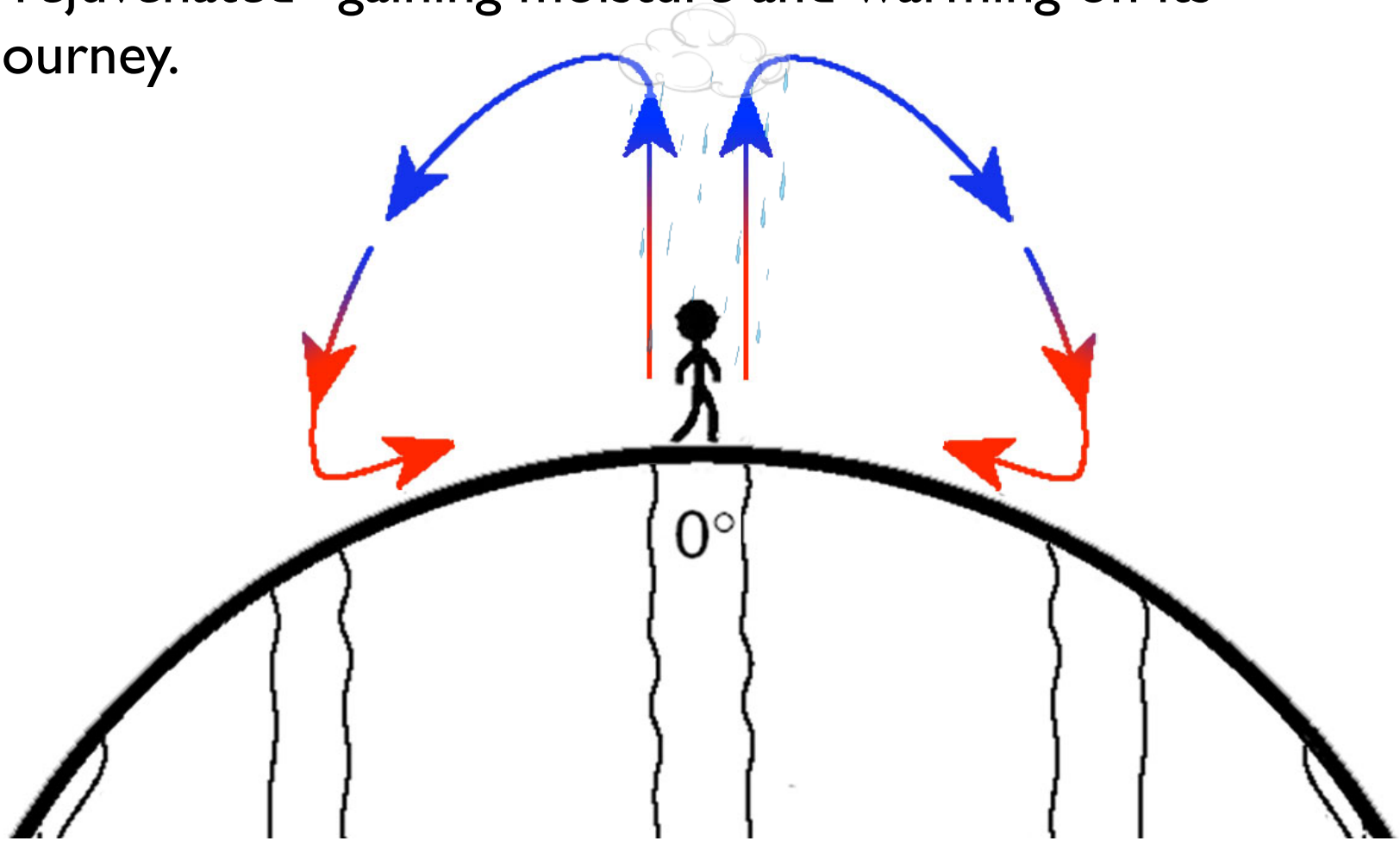
Convection & Moisture Belts

- As the air descends toward earth's surface it warms due to the increase in atmospheric pressure.
- The sinking air is drier compared to the air originating at the equator.



Convection & Moisture Belts

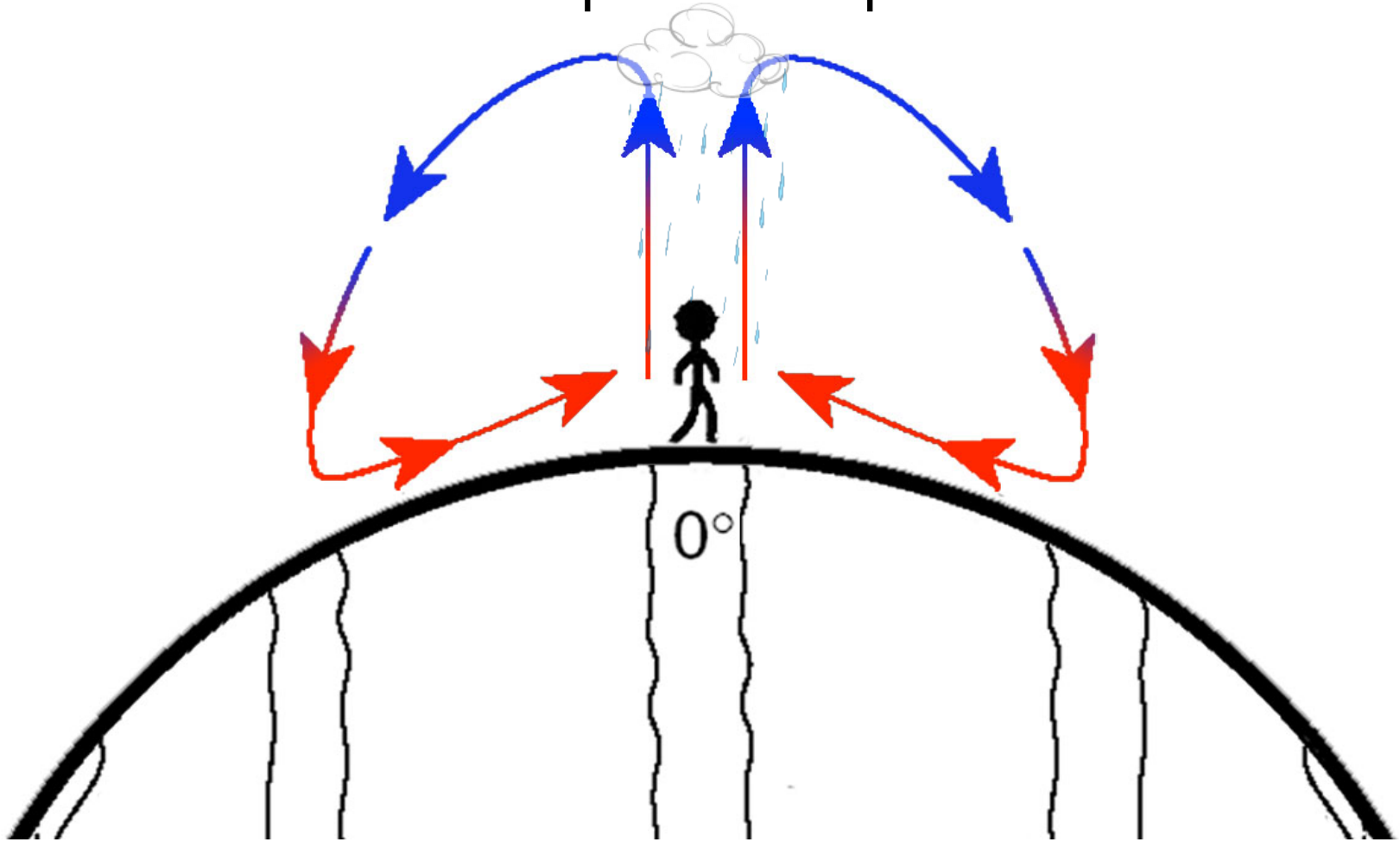
- As the air descends toward earth's surface it warms due to the increase in atmospheric pressure.
- Much of the air converges toward the equator – it will be "rejuvenated" gaining moisture and warming on its journey.



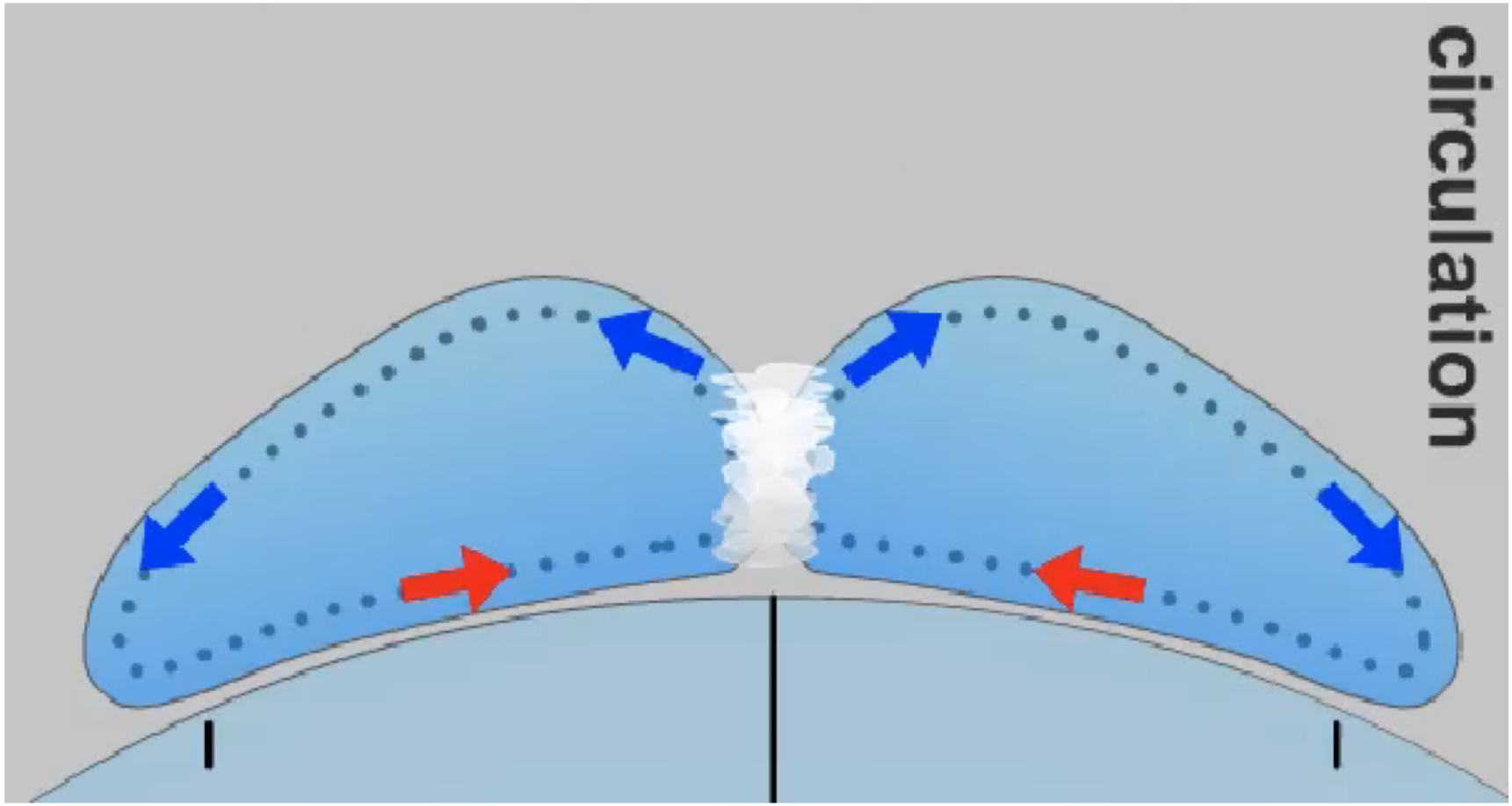
Convection & Moisture Belts

- The cycle is complete as the air arrives at the equator to eventually rise again.

We'll now watch the entire process looped in an animation…



Convection & Moisture Belts

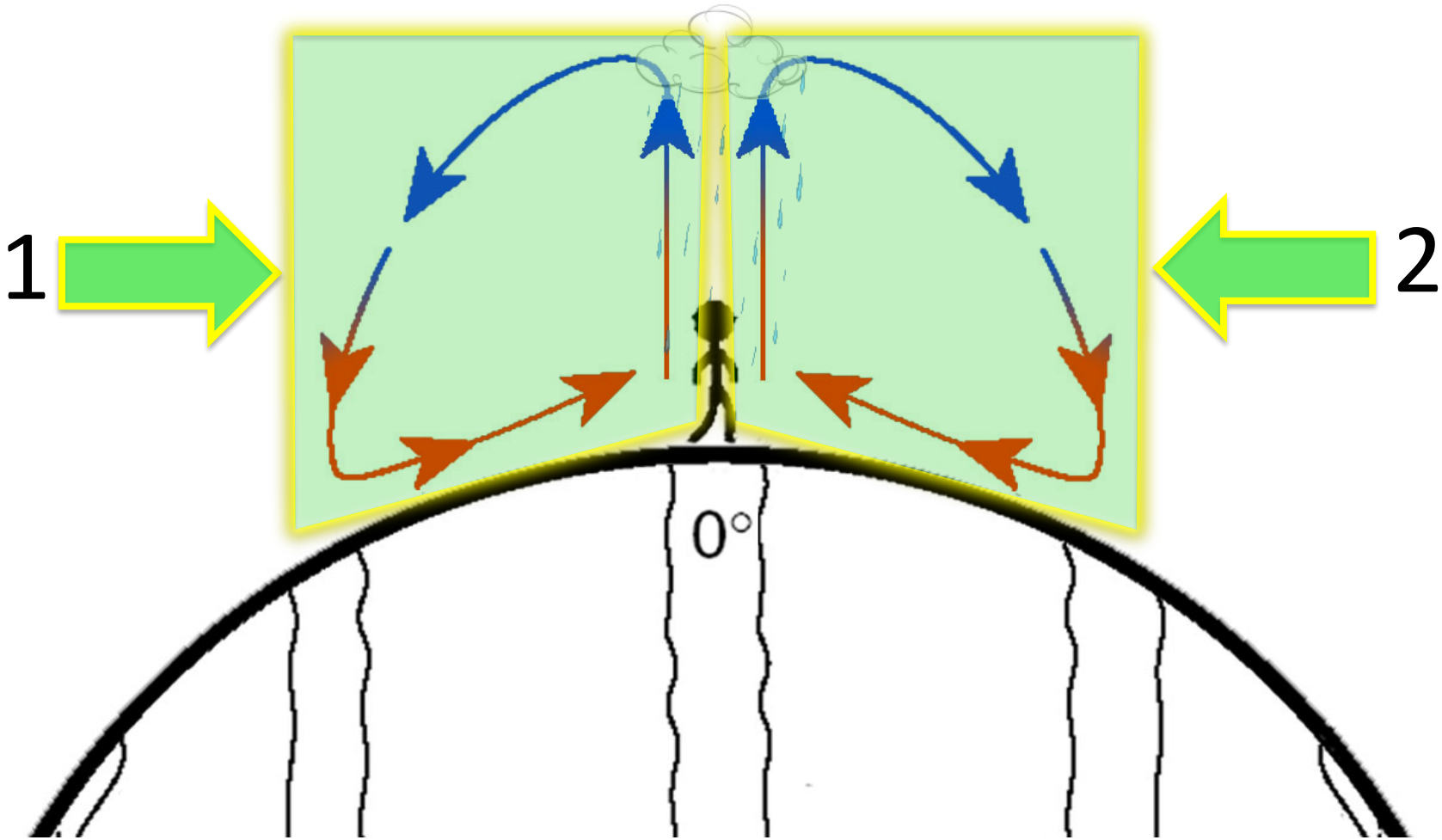


The entire process is a classic example of **"convection"** – the transfer of heat by movement of air or a liquid.*

*Note that moisture transfer is not a requirement for convection to occur, although it is important within meteorology.

Convection & Moisture Belts

- The **convection** shown below can also be referred to as two somewhat independent **convection cells**.

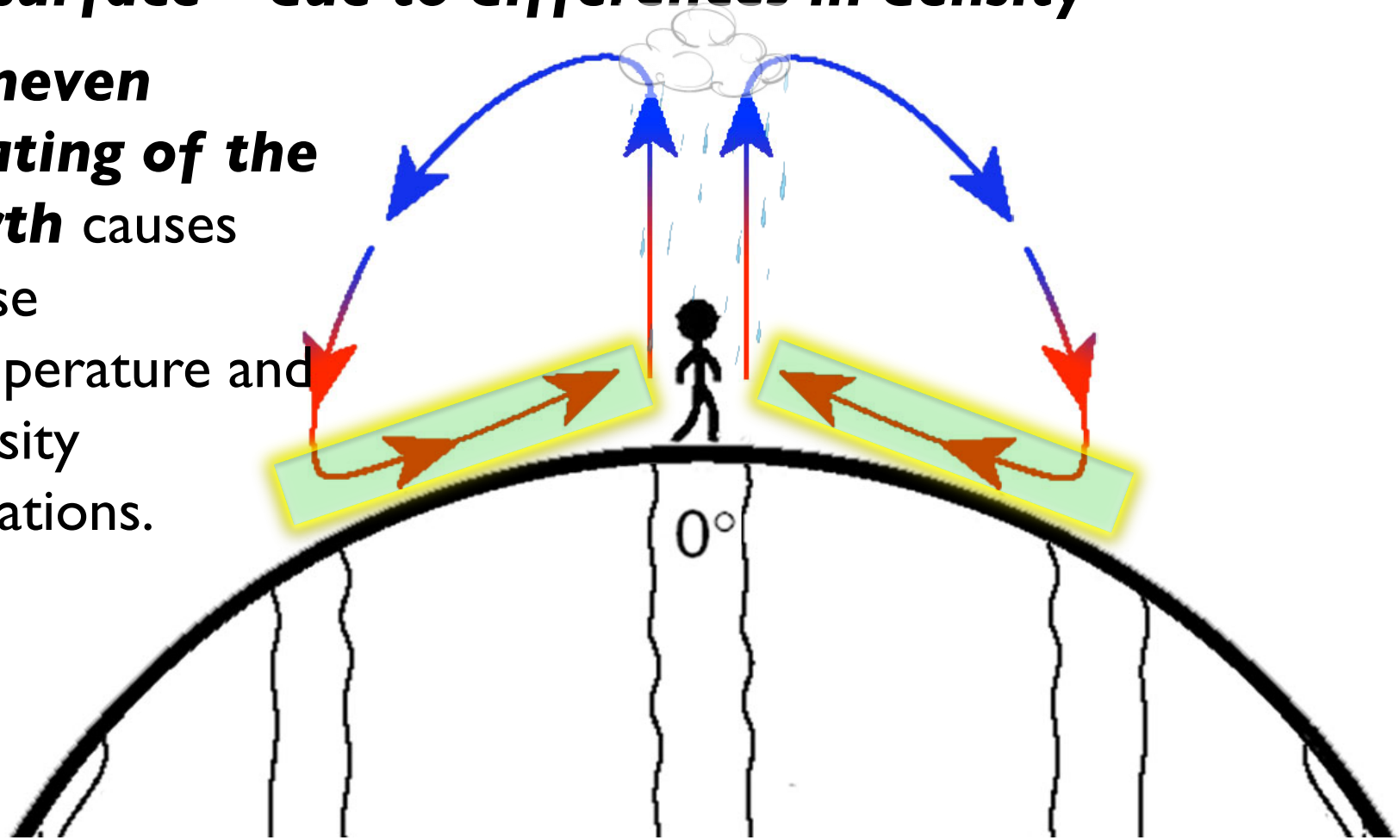


Convection & Moisture Belts

The bottom "leg" of a convection current is **Wind:**

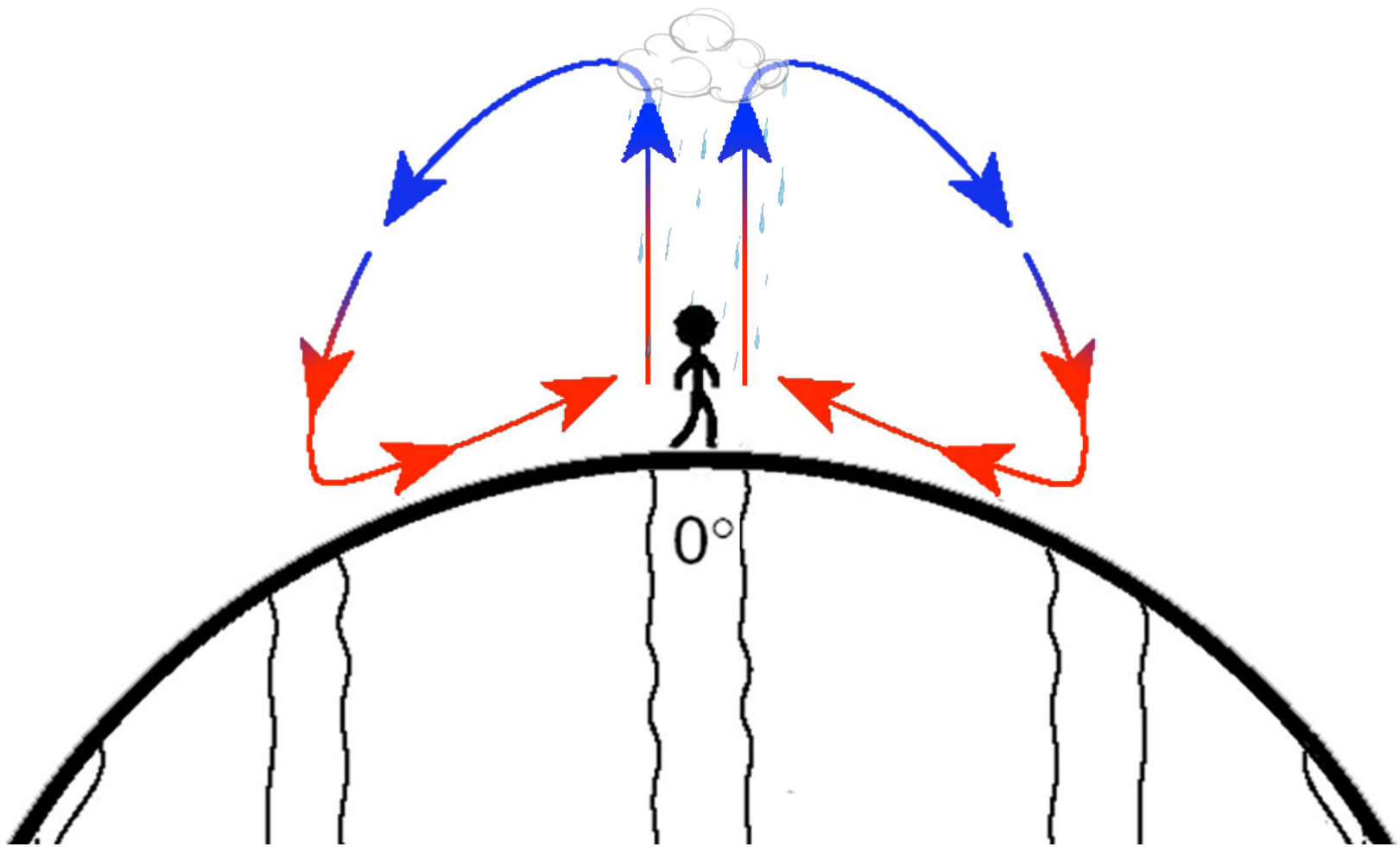
the movement of air – parallel to earth's surface – due to differences in density

****Uneven heating of the earth*** causes these temperature and density variations.



Convection & Moisture Belts

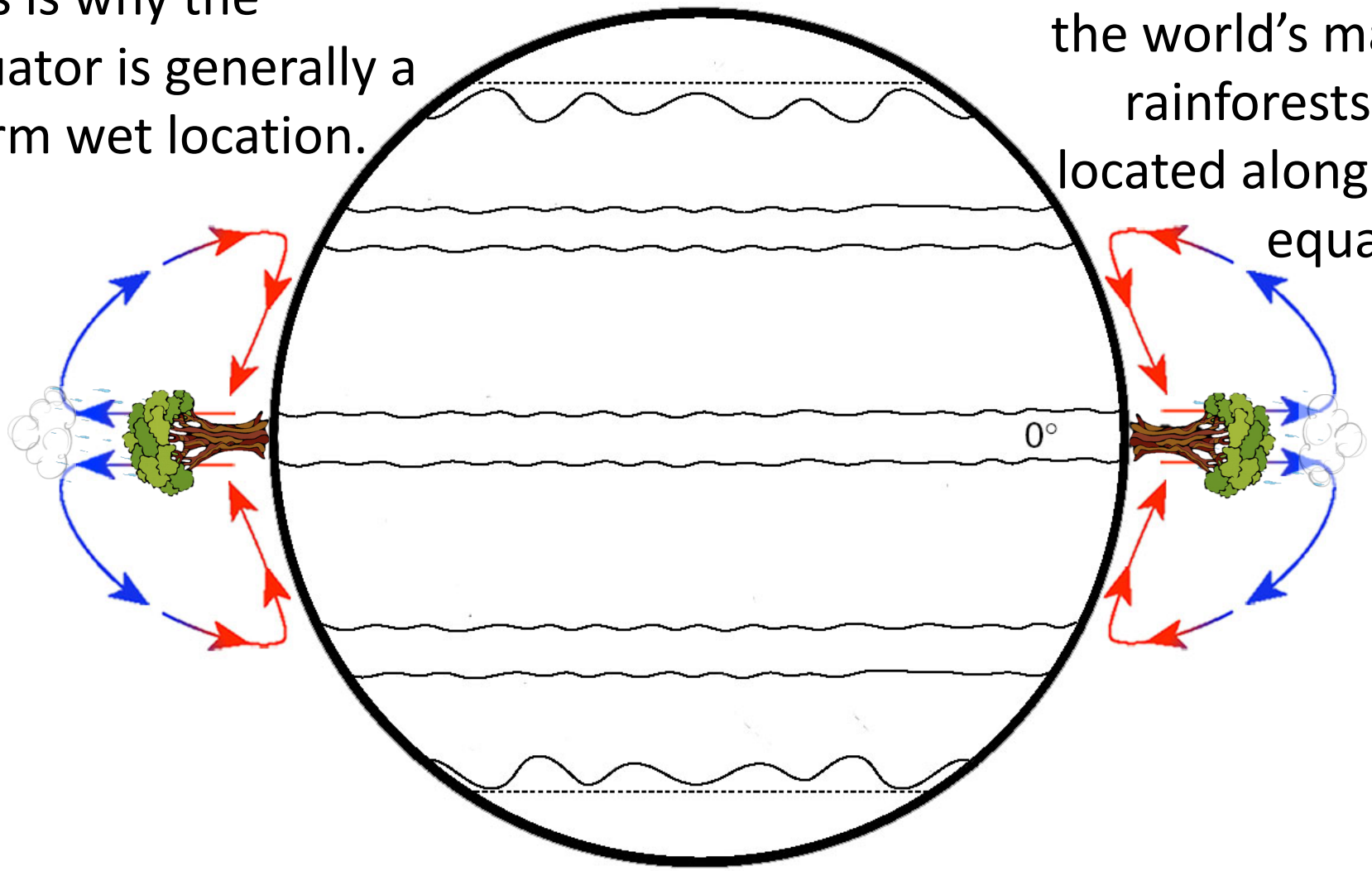
- The convection cell model shown below (focusing on the equator) can be rotated and viewed on a global scale…



Convection & Moisture Belts

This is why the equator is generally a warm wet location.

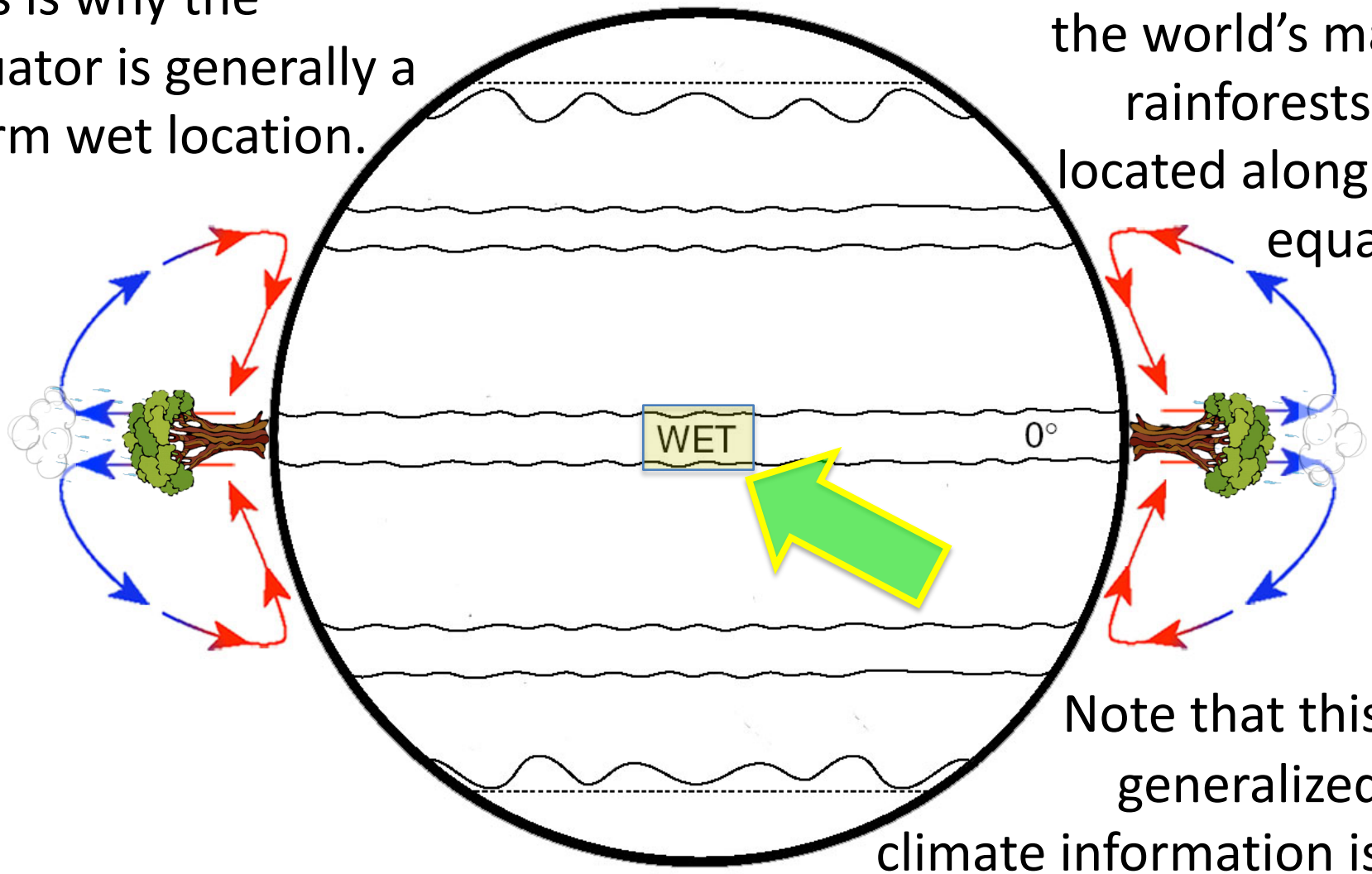
It also explains why the world's major rainforests are located along the equator.



Convection & Moisture Belts

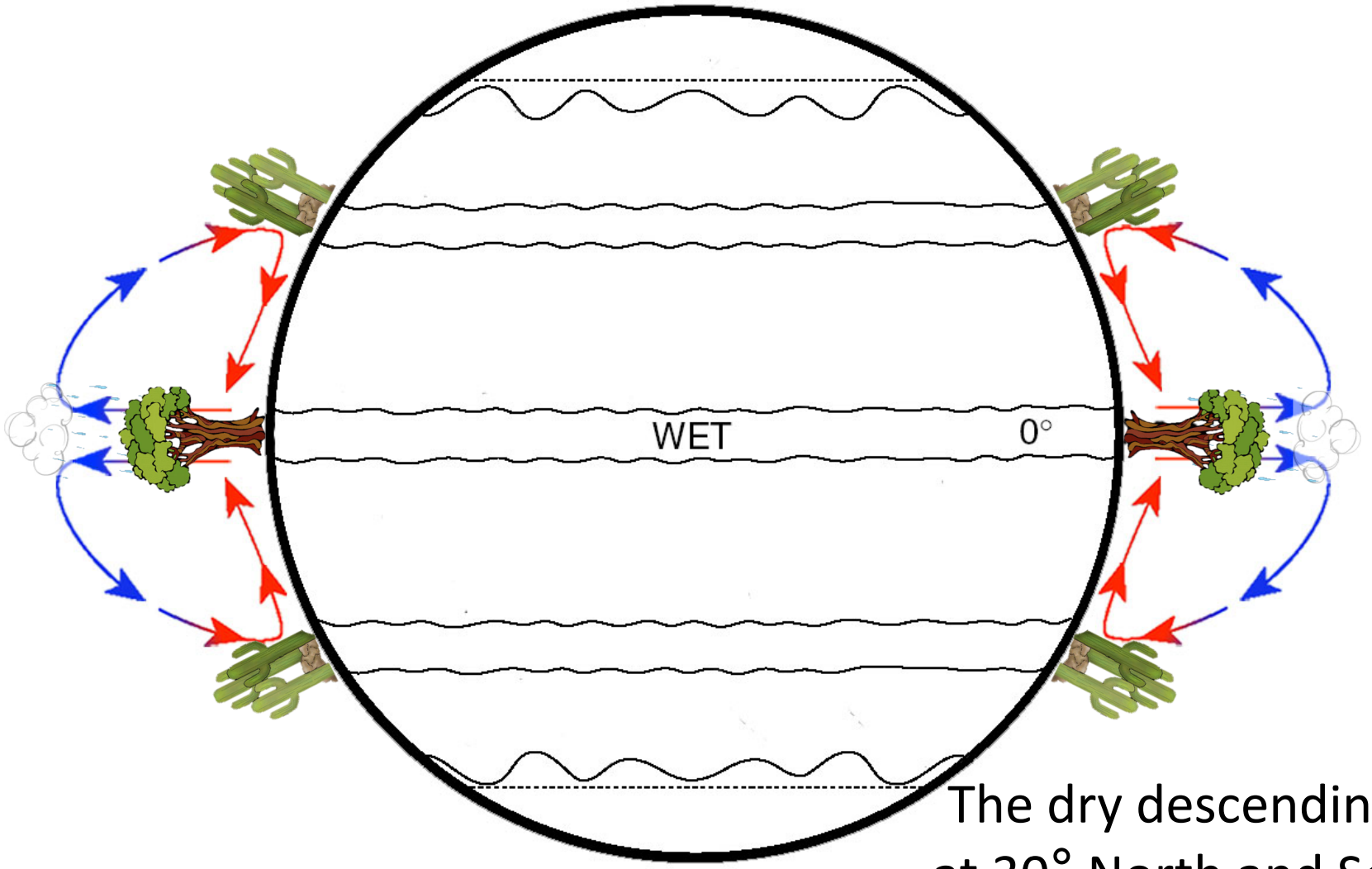
This is why the equator is generally a warm wet location.

It also explains why the world's major rainforests are located along the equator.



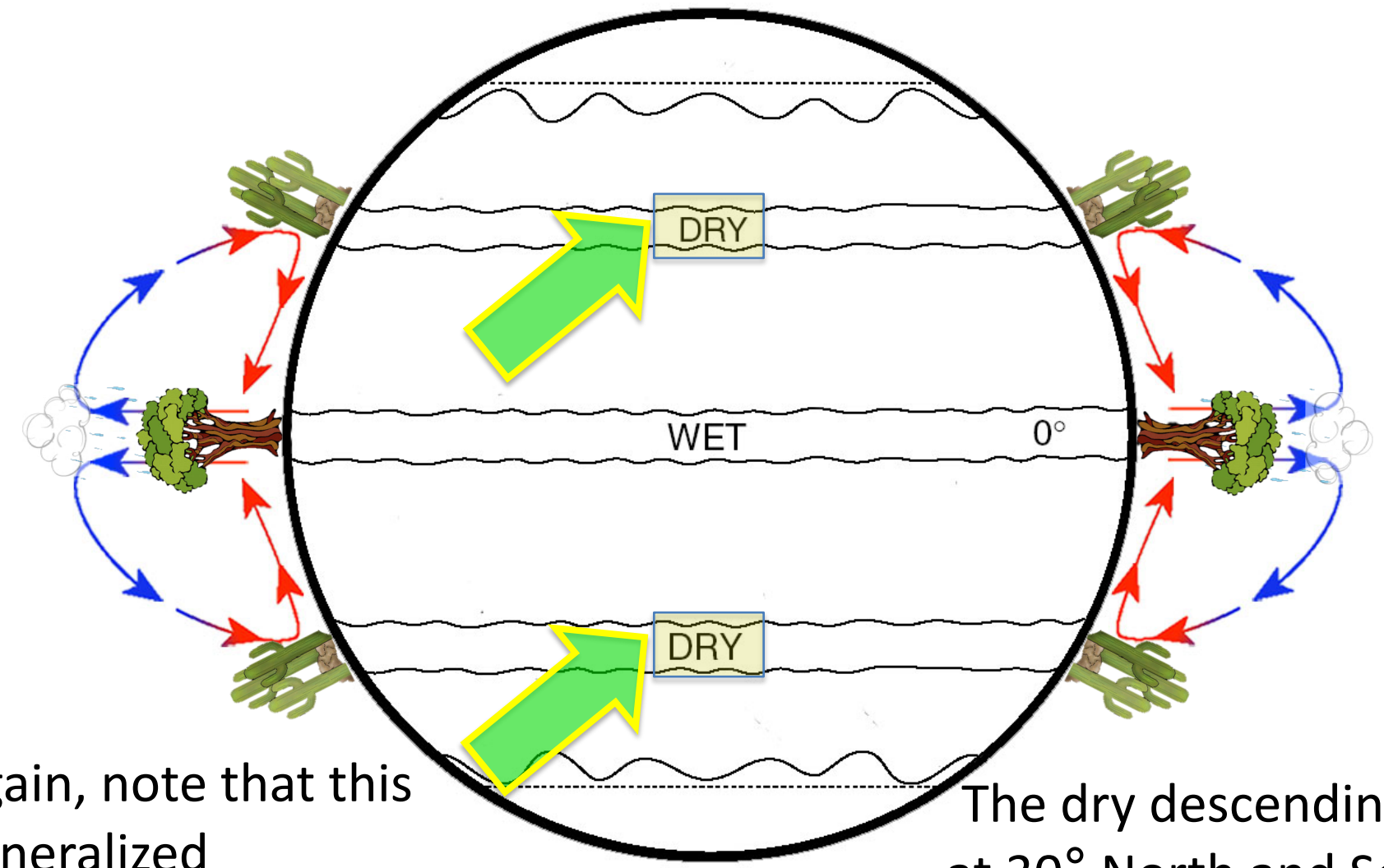
Note that this generalized climate information is noted here for you.

Convection & Moisture Belts



The dry descending air at 30° North and South Latitude explains large desert regions found along this

Convection & Moisture Belts



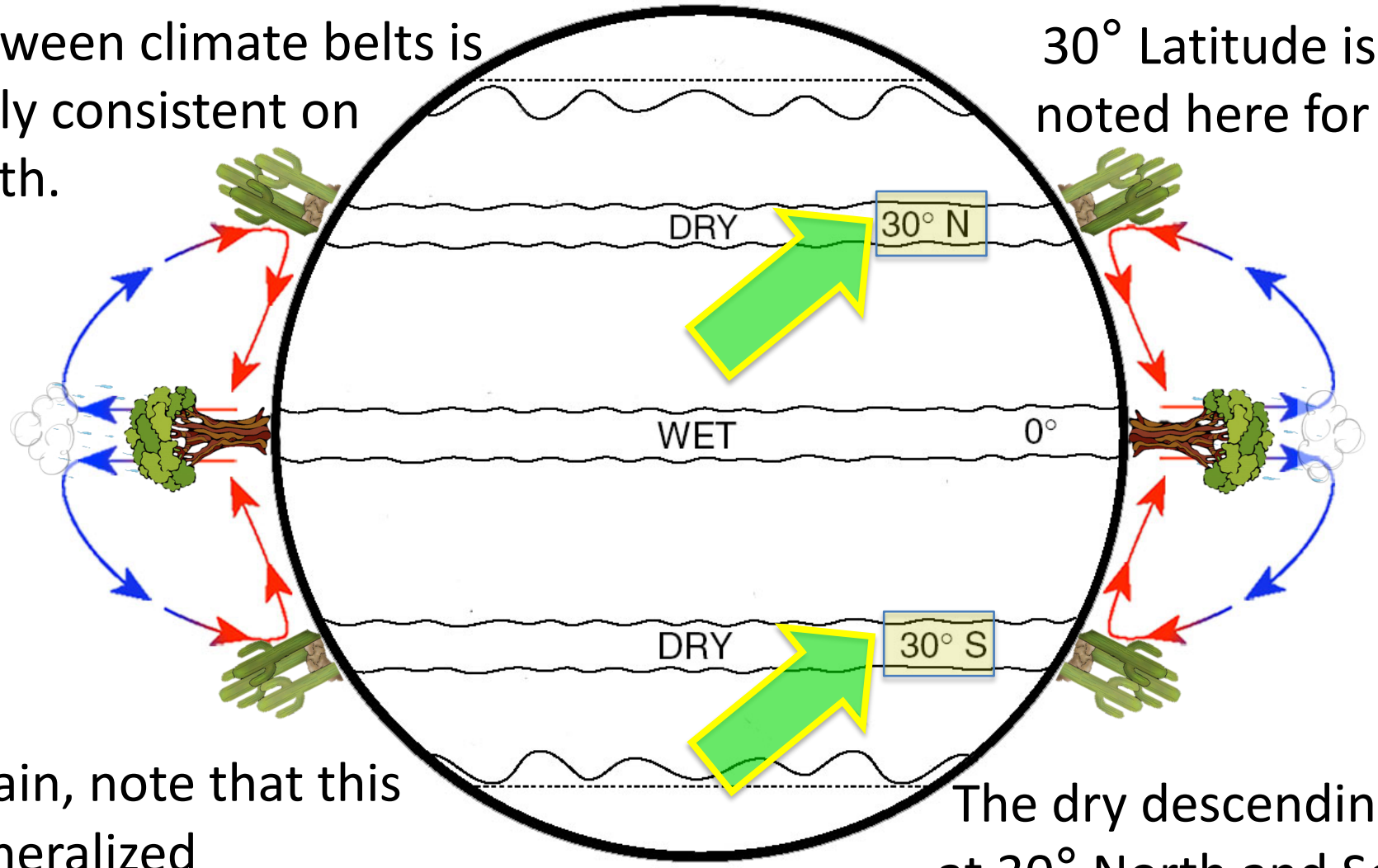
Again, note that this generalized climate information is noted here for you.

The dry descending air at 30° North and South Latitude explains large desert regions found along this

Convection & Moisture Belts

Note that the separation between climate belts is fairly consistent on earth.

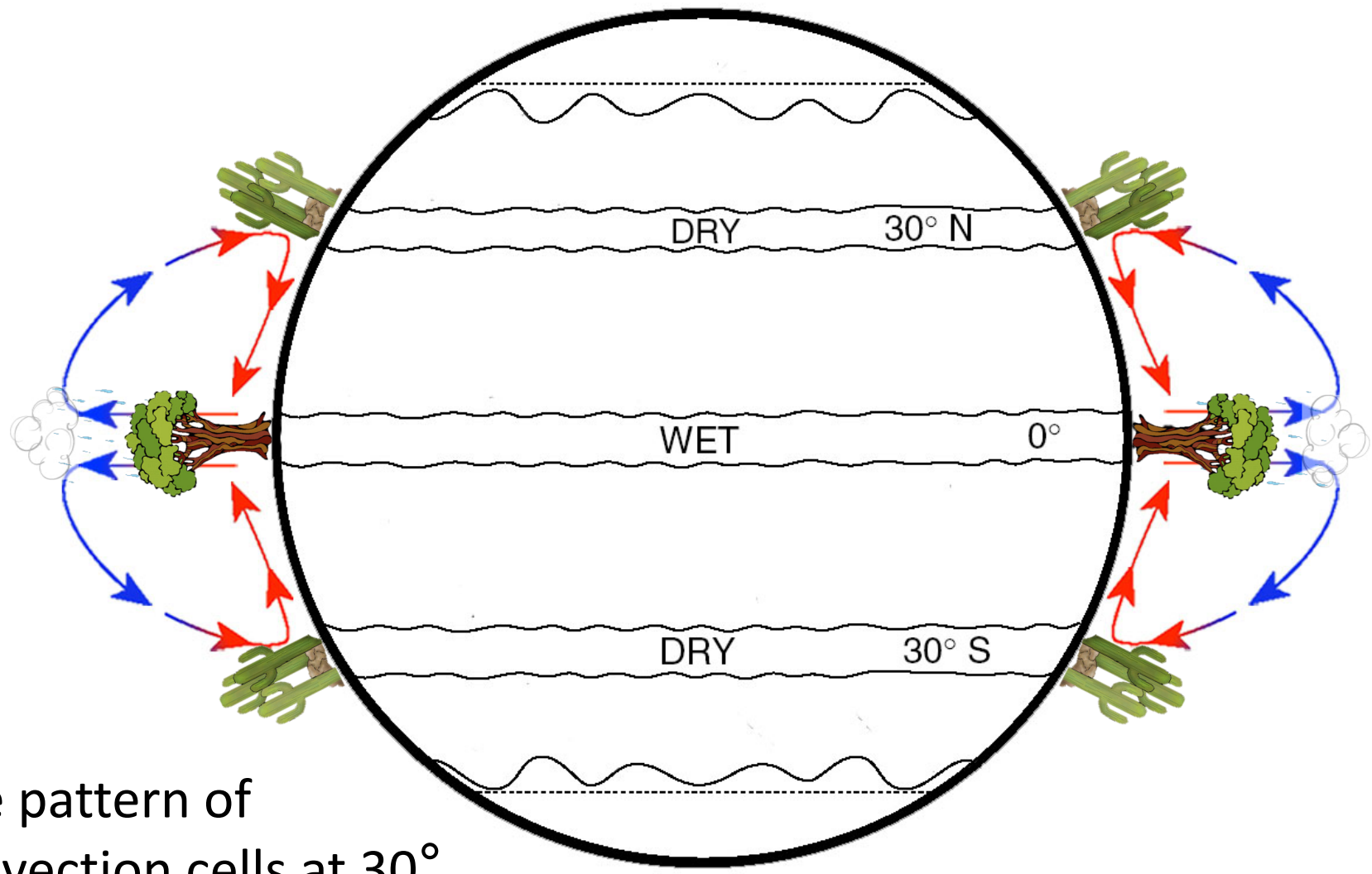
These divisions of 30° Latitude is also noted here for you.



Again, note that this generalized climate information is noted here for you.

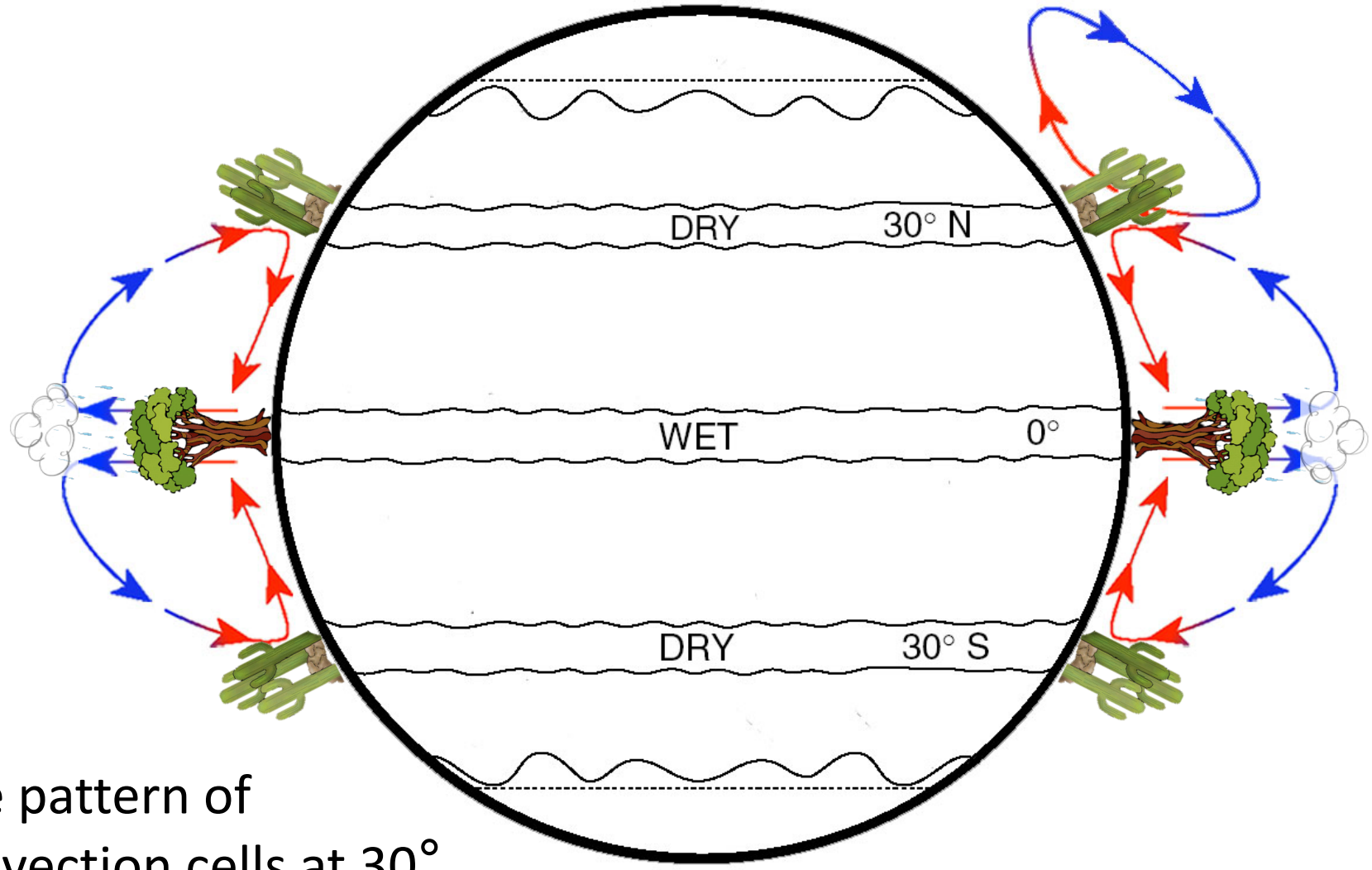
The dry descending air at 30° North and South Latitude explains large desert regions found along this

Convection & Moisture Belts



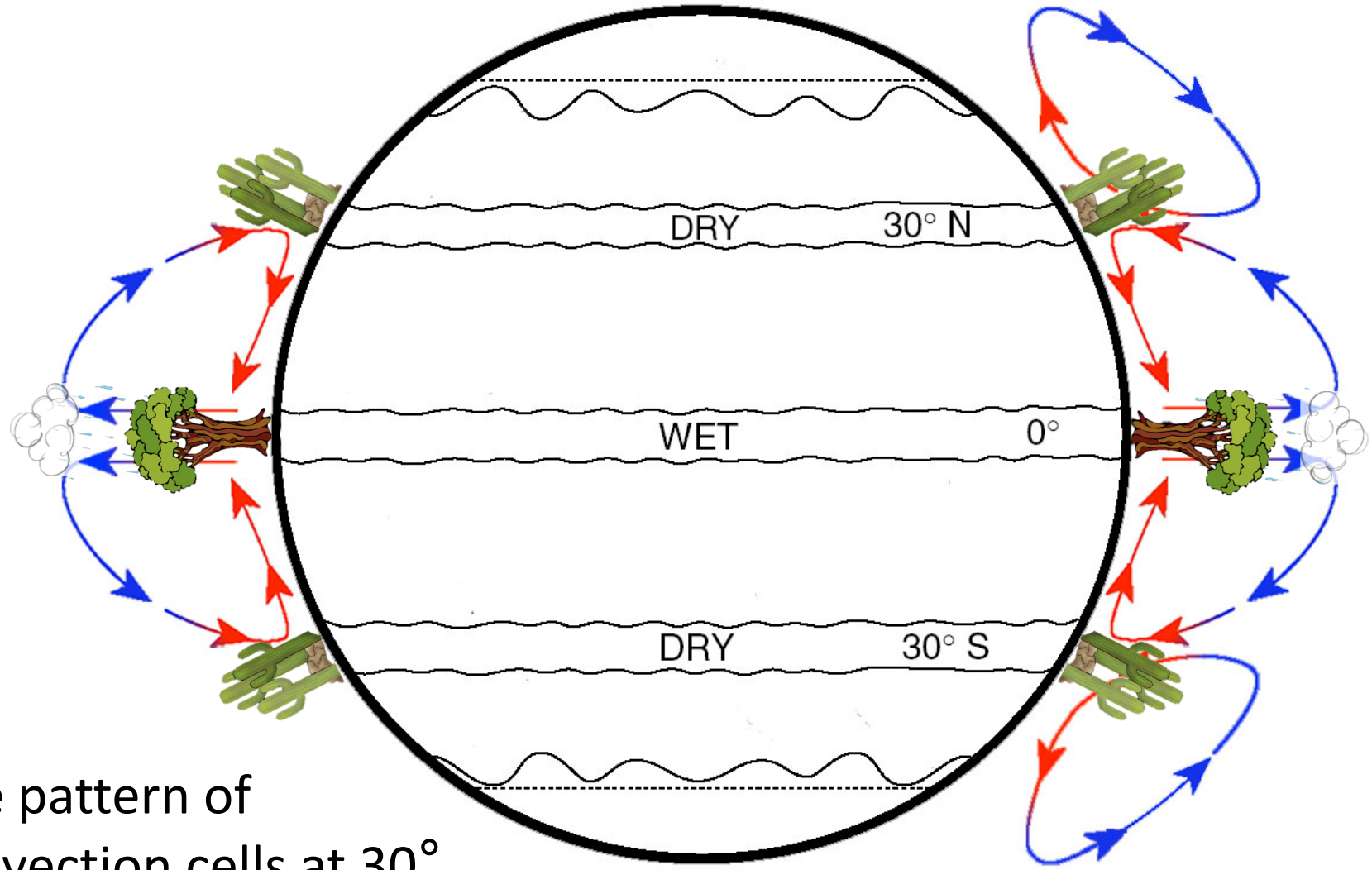
The pattern of convection cells at 30° Latitude intervals continues…

Convection & Moisture Belts



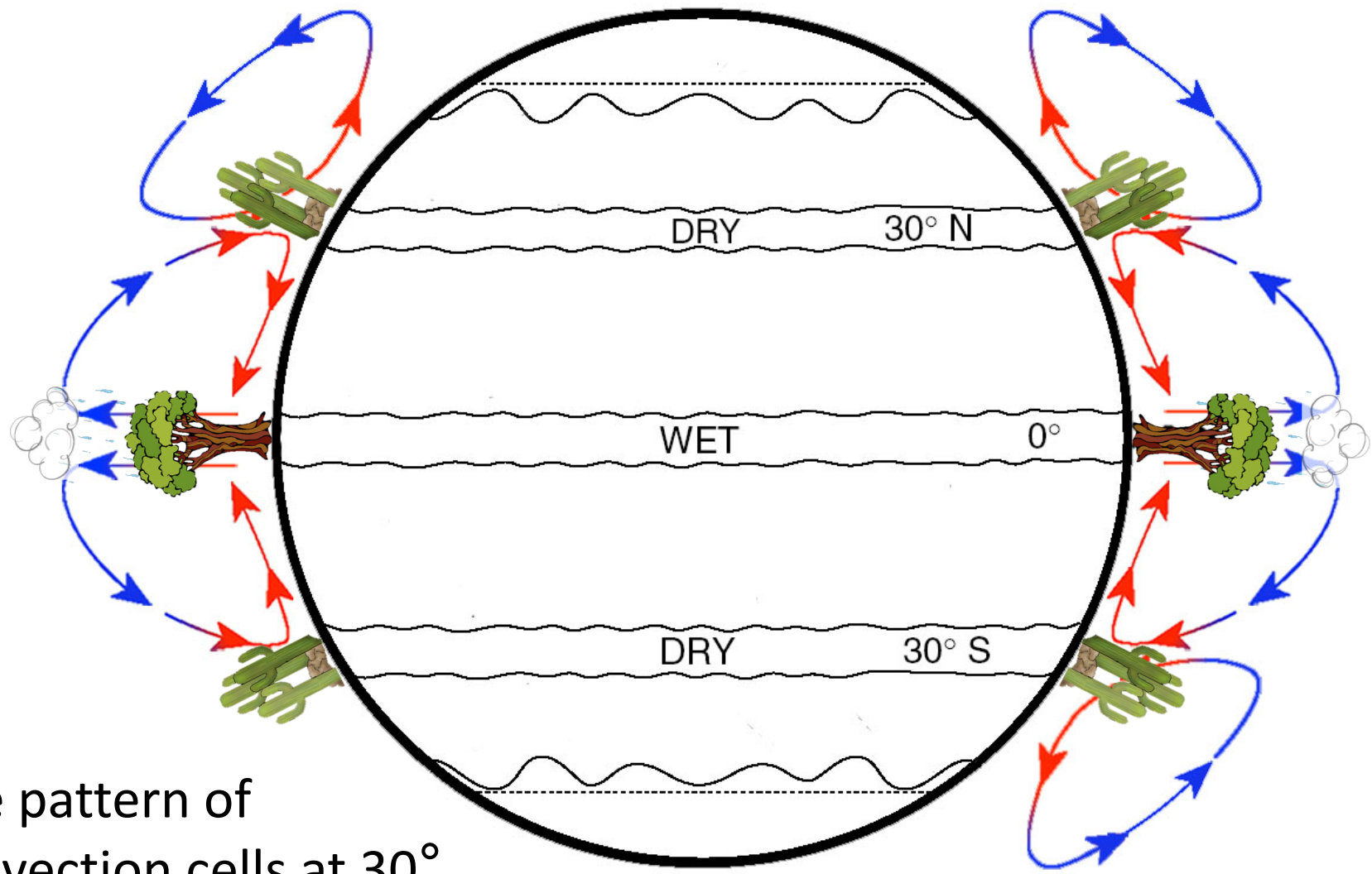
The pattern of convection cells at 30° Latitude intervals continues…

Convection & Moisture Belts



The pattern of convection cells at 30° Latitude intervals continues…

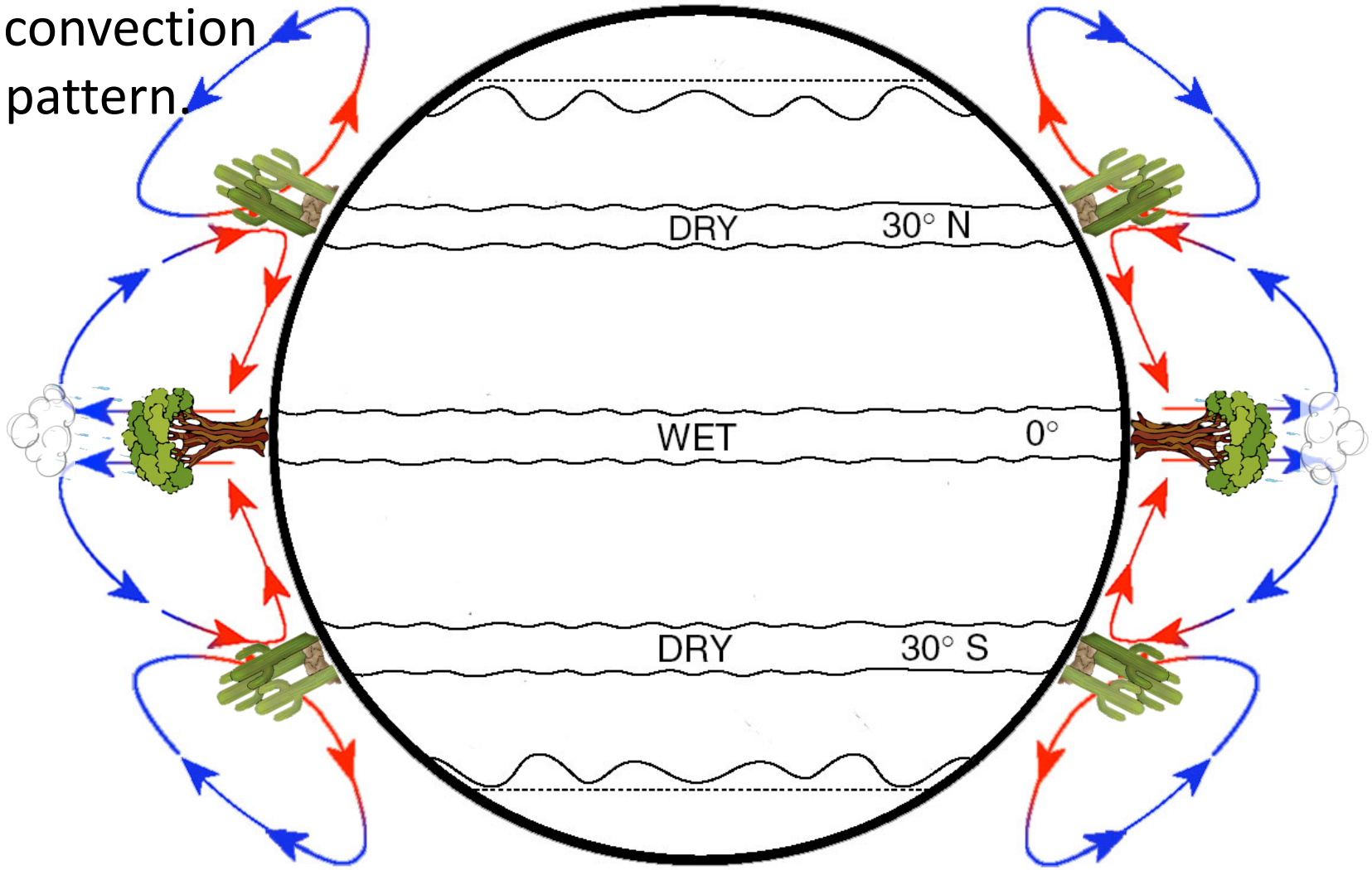
Convection & Moisture Belts



The pattern of convection cells at 30° Latitude intervals continues…

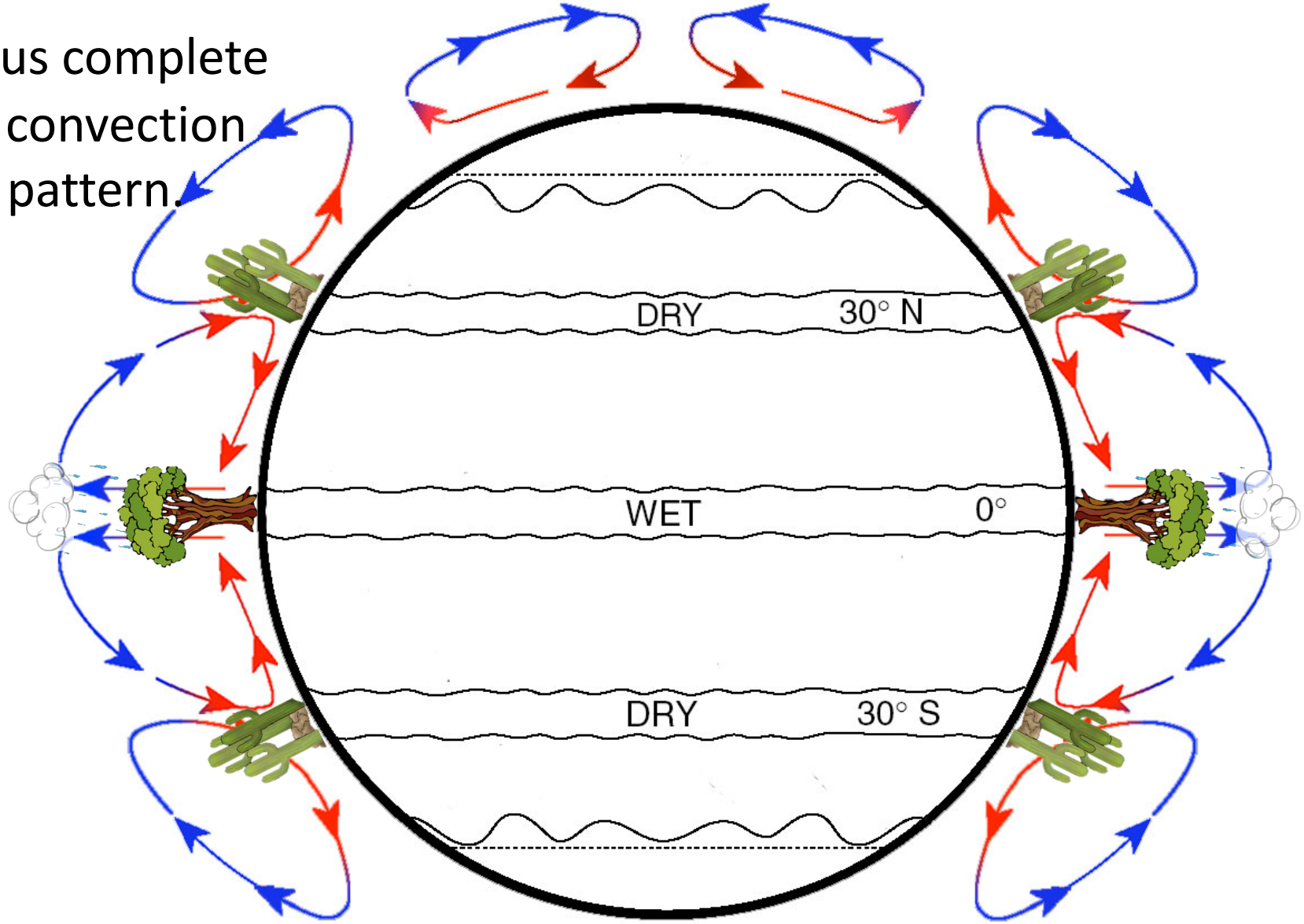
Convection & Moisture Belts

Let us complete the convection cell pattern.



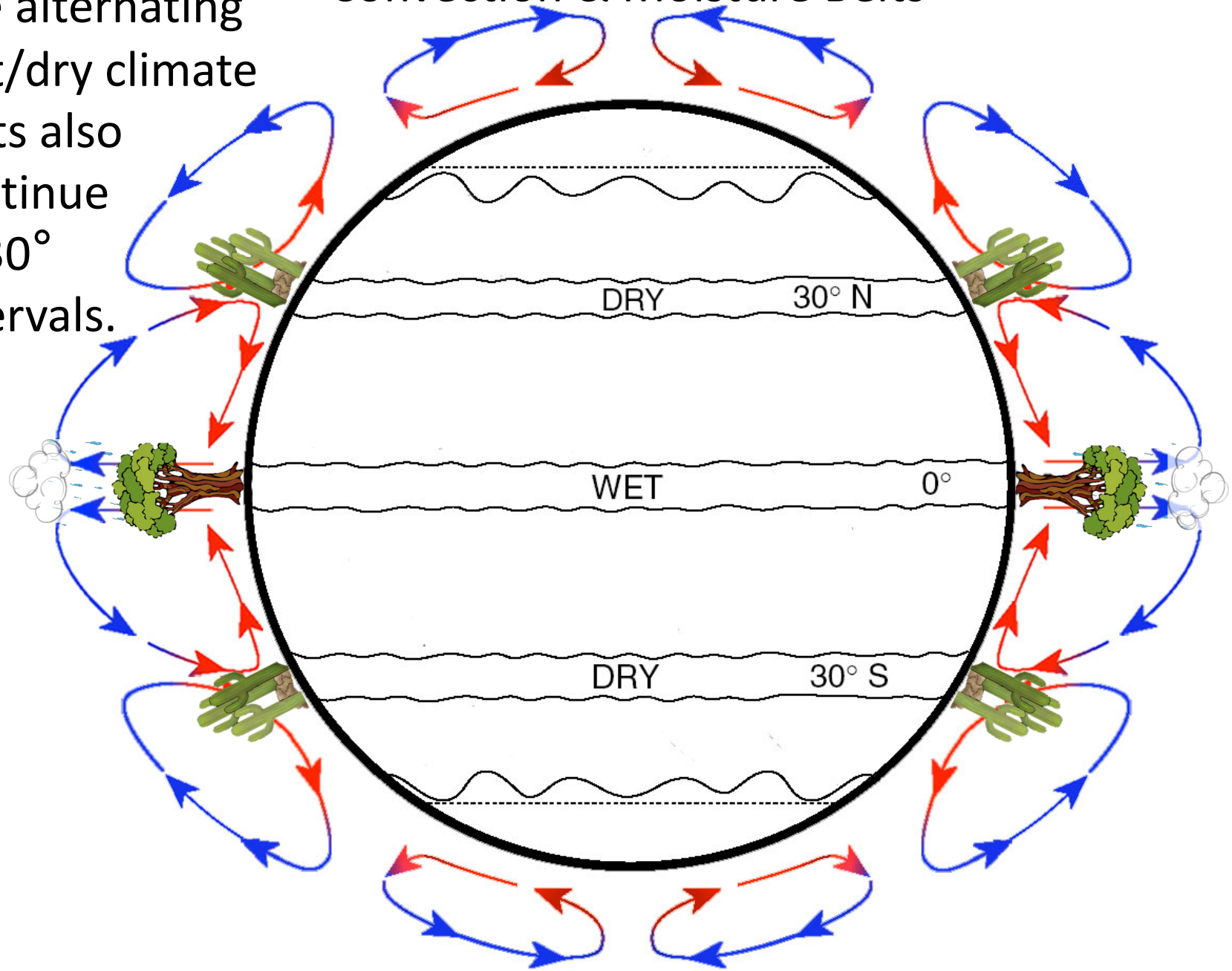
Convection & Moisture Belts

Let us complete the convection cell pattern.



Convection & Moisture Belts

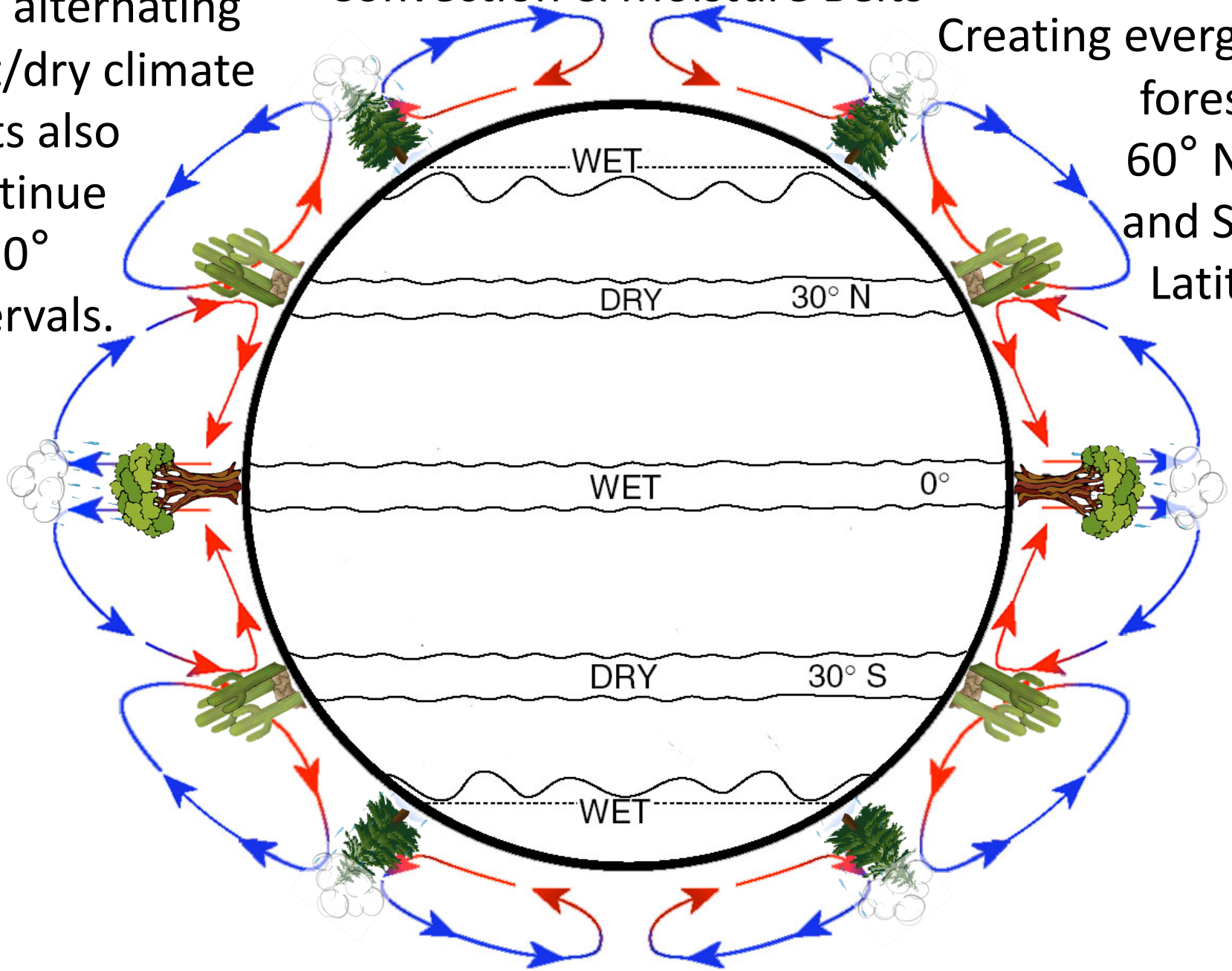
The alternating wet/dry climate belts also continue at 30° intervals.



Convection & Moisture Belts

The alternating wet/dry climate belts also continue at 30° intervals.

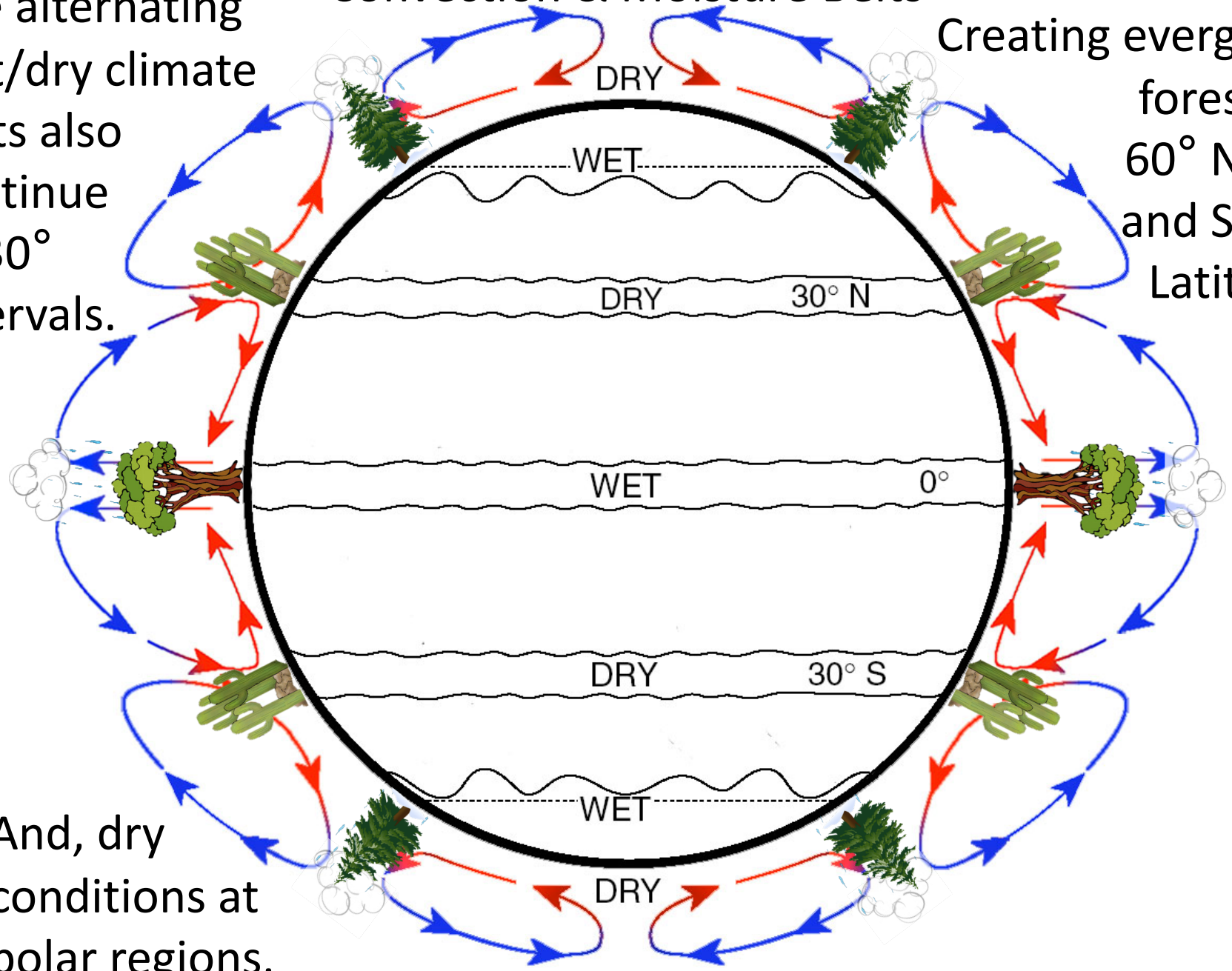
Creating evergreen forests at 60° North and South Latitude.



Convection & Moisture Belts

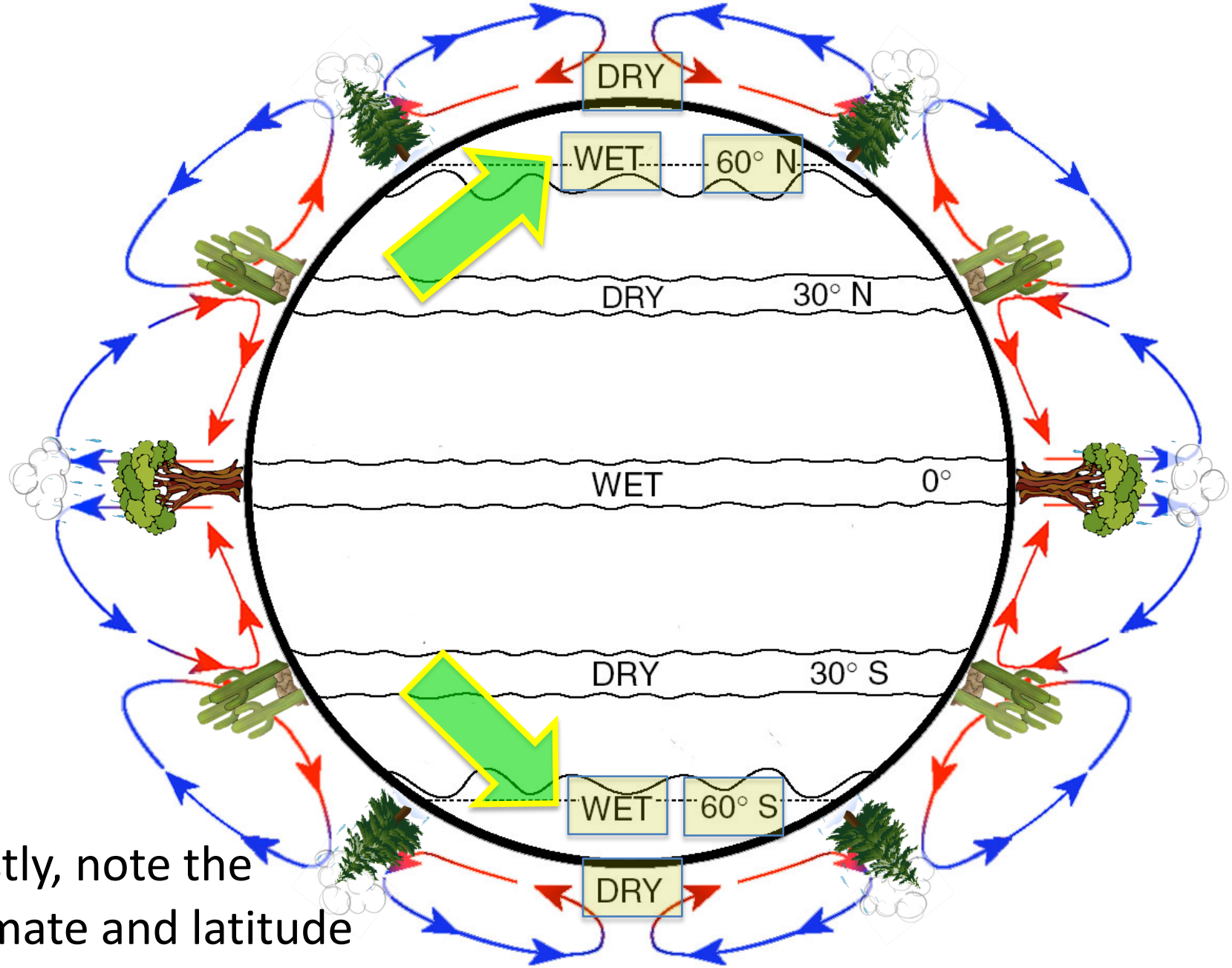
The alternating wet/dry climate belts also continue at 30° intervals.

Creating evergreen forests at 60° North and South Latitude.



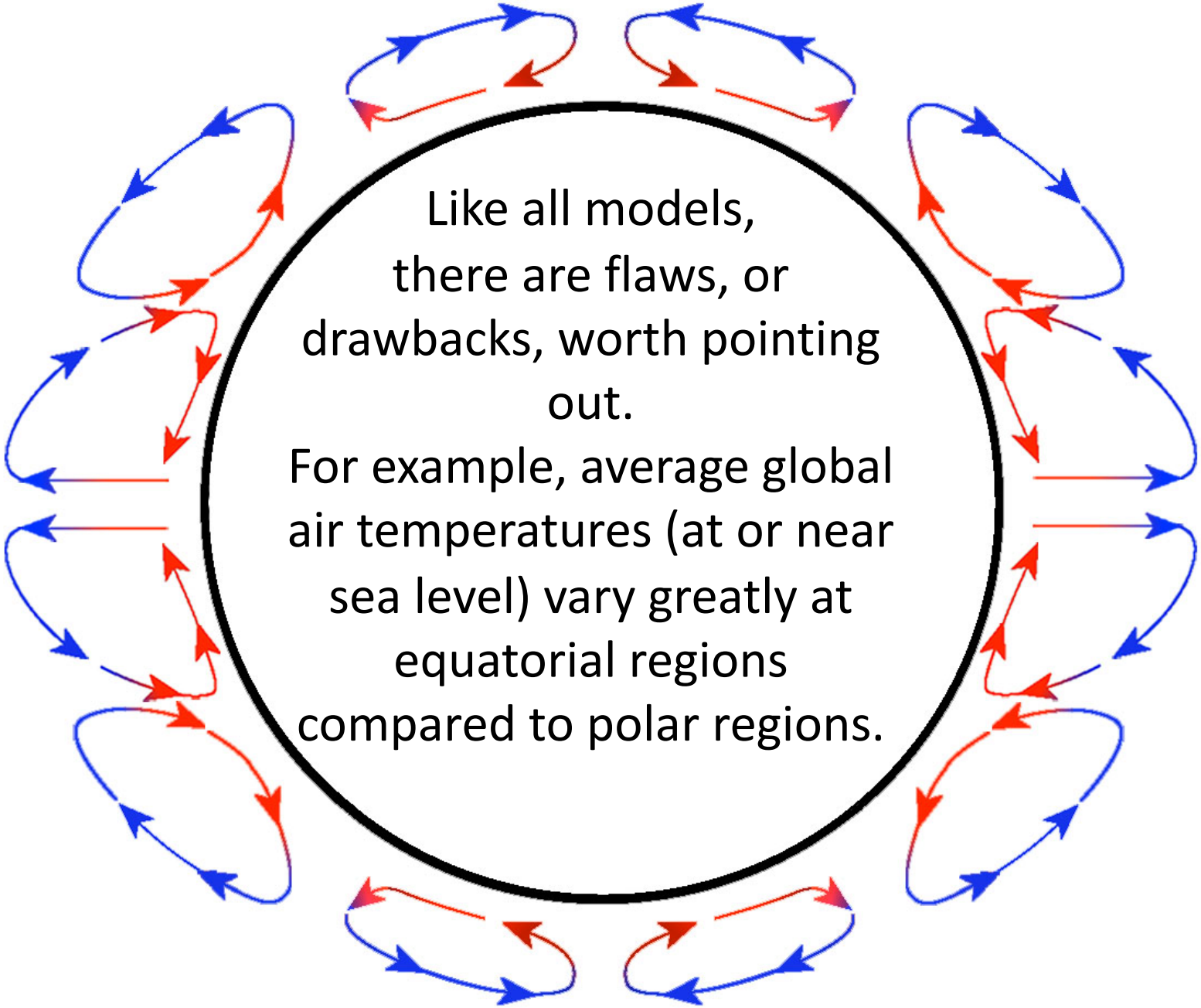
And, dry conditions at polar regions.

Convection & Moisture Belts



Lastly, note the climate and latitude polar region information is also noted for you.

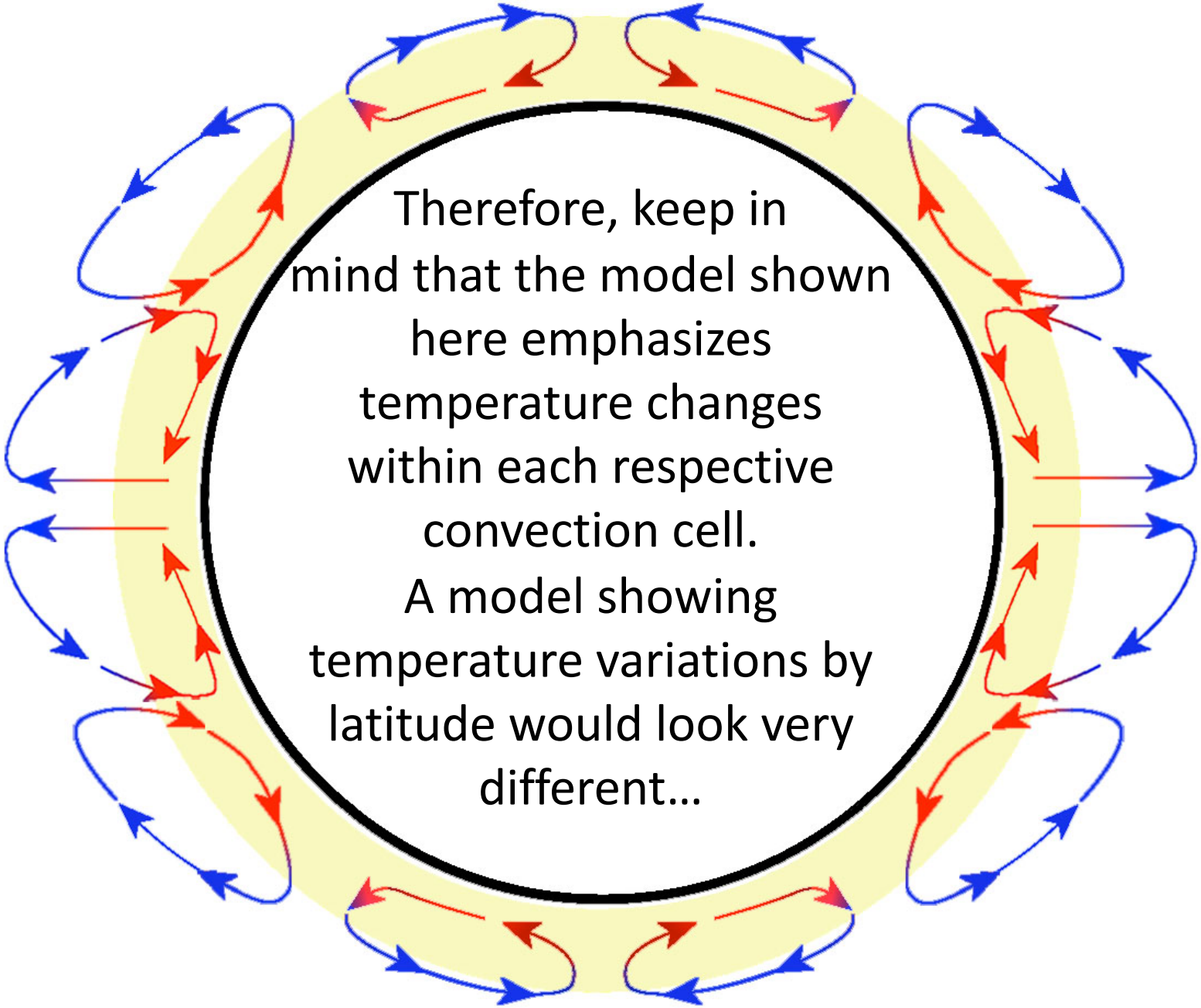
Convection & Moisture Belts



Like all models, there are flaws, or drawbacks, worth pointing out.

For example, average global air temperatures (at or near sea level) vary greatly at equatorial regions compared to polar regions.

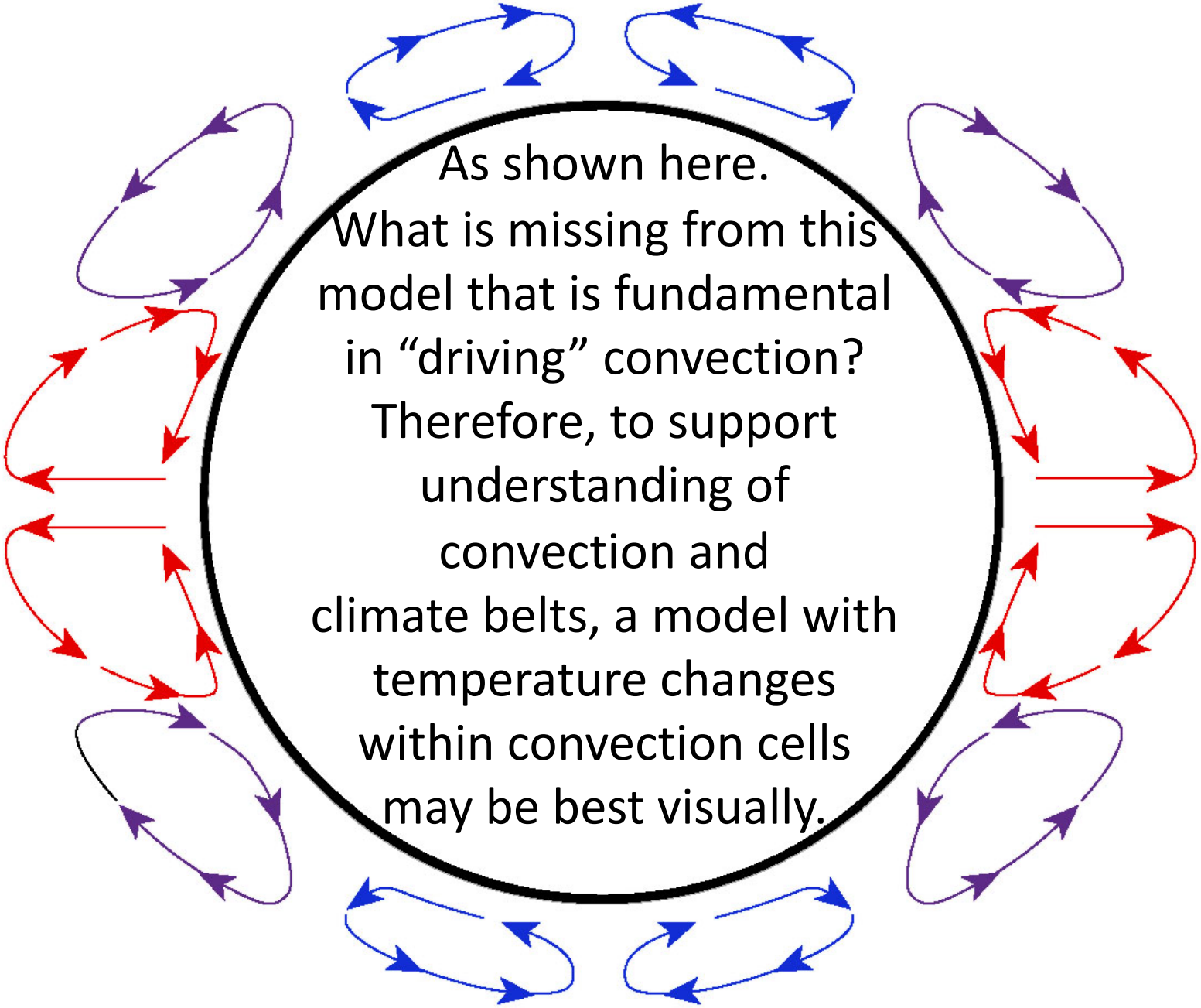
Convection & Moisture Belts



Therefore, keep in mind that the model shown here emphasizes temperature changes within each respective convection cell.

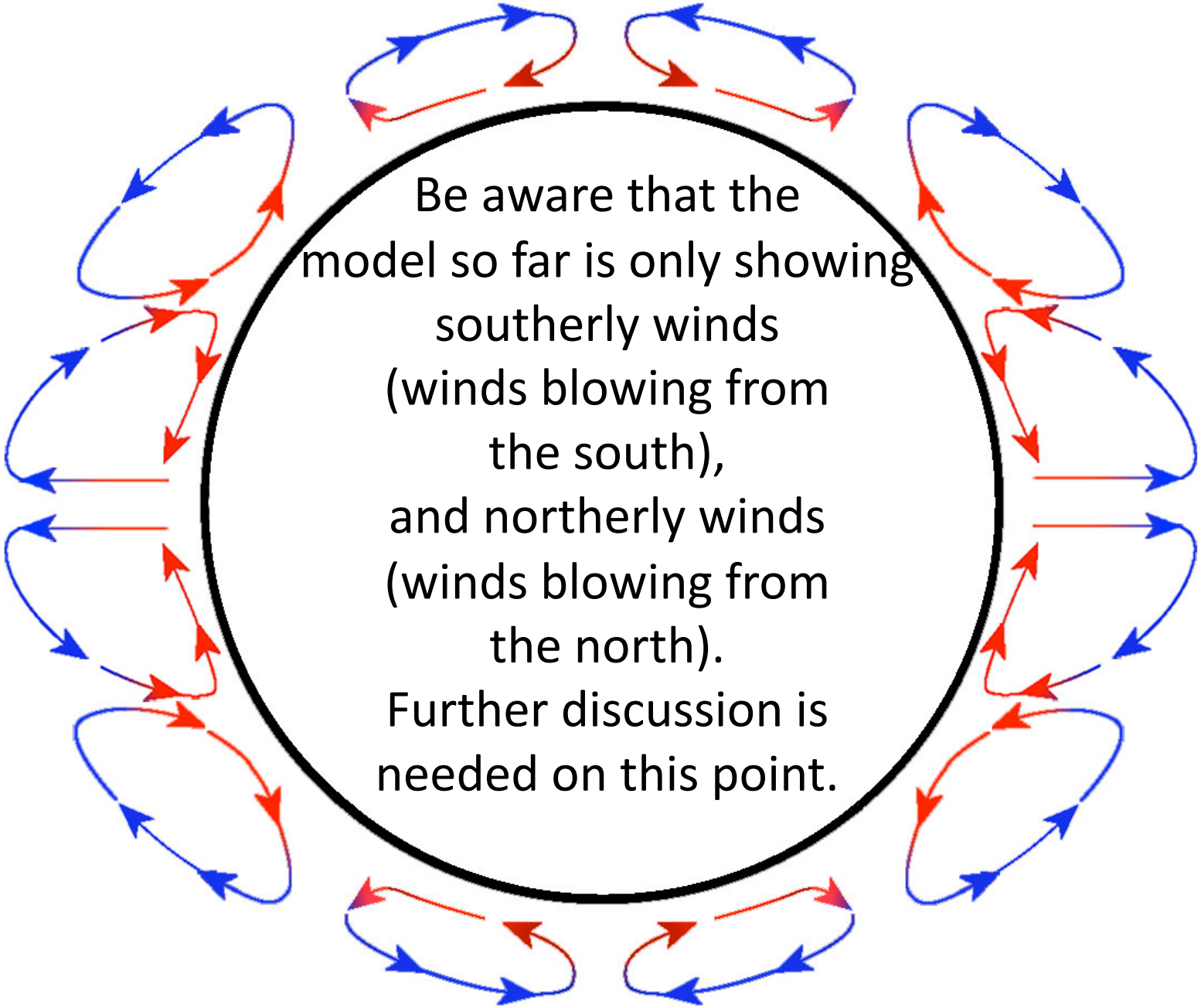
A model showing temperature variations by latitude would look very different…

Convection & Moisture Belts



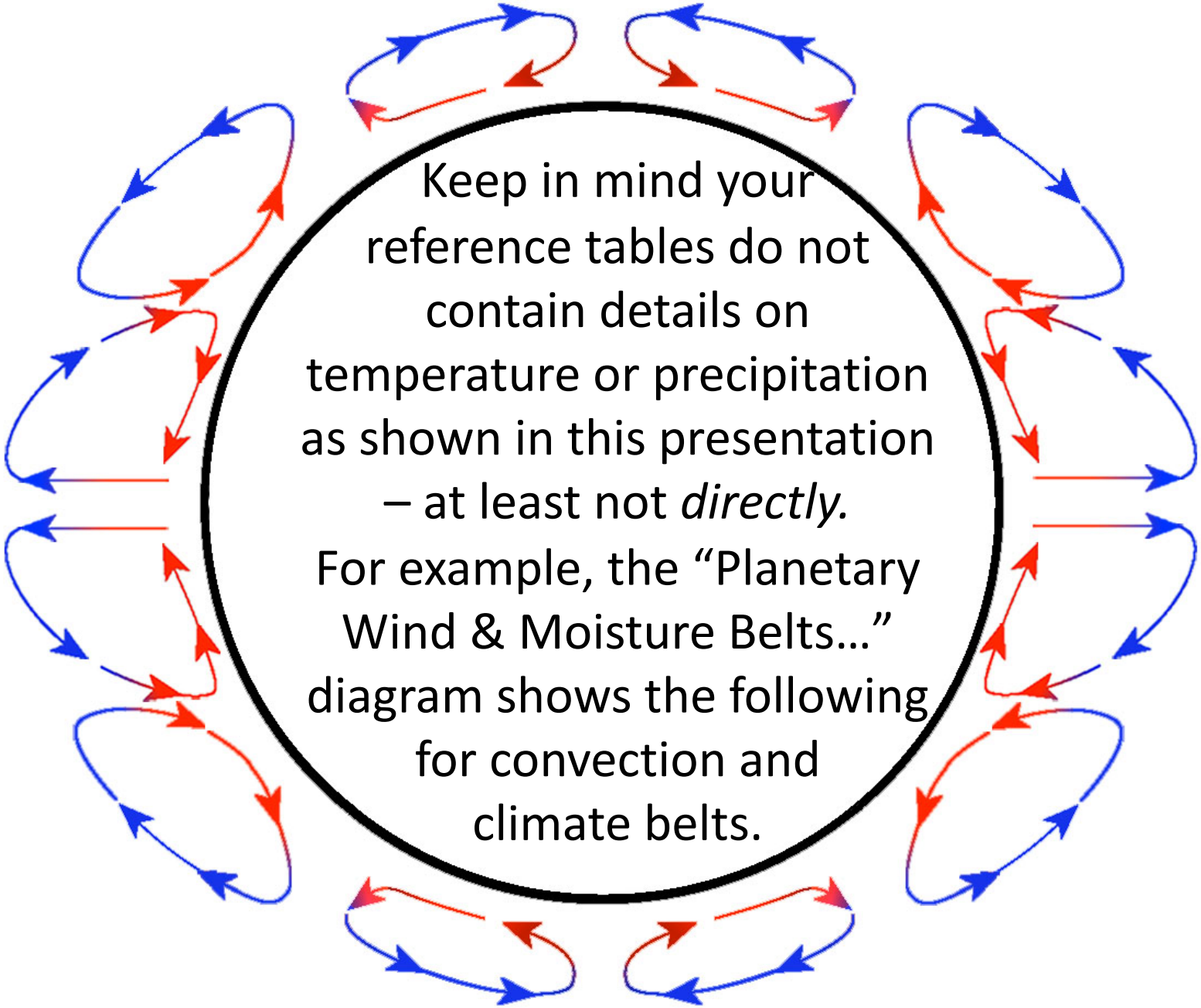
As shown here.
What is missing from this model that is fundamental in “driving” convection?
Therefore, to support understanding of convection and climate belts, a model with temperature changes within convection cells may be best visually.

Convection & Moisture Belts



Be aware that the model so far is only showing southerly winds (winds blowing from the south), and northerly winds (winds blowing from the north). Further discussion is needed on this point.

Convection & Moisture Belts

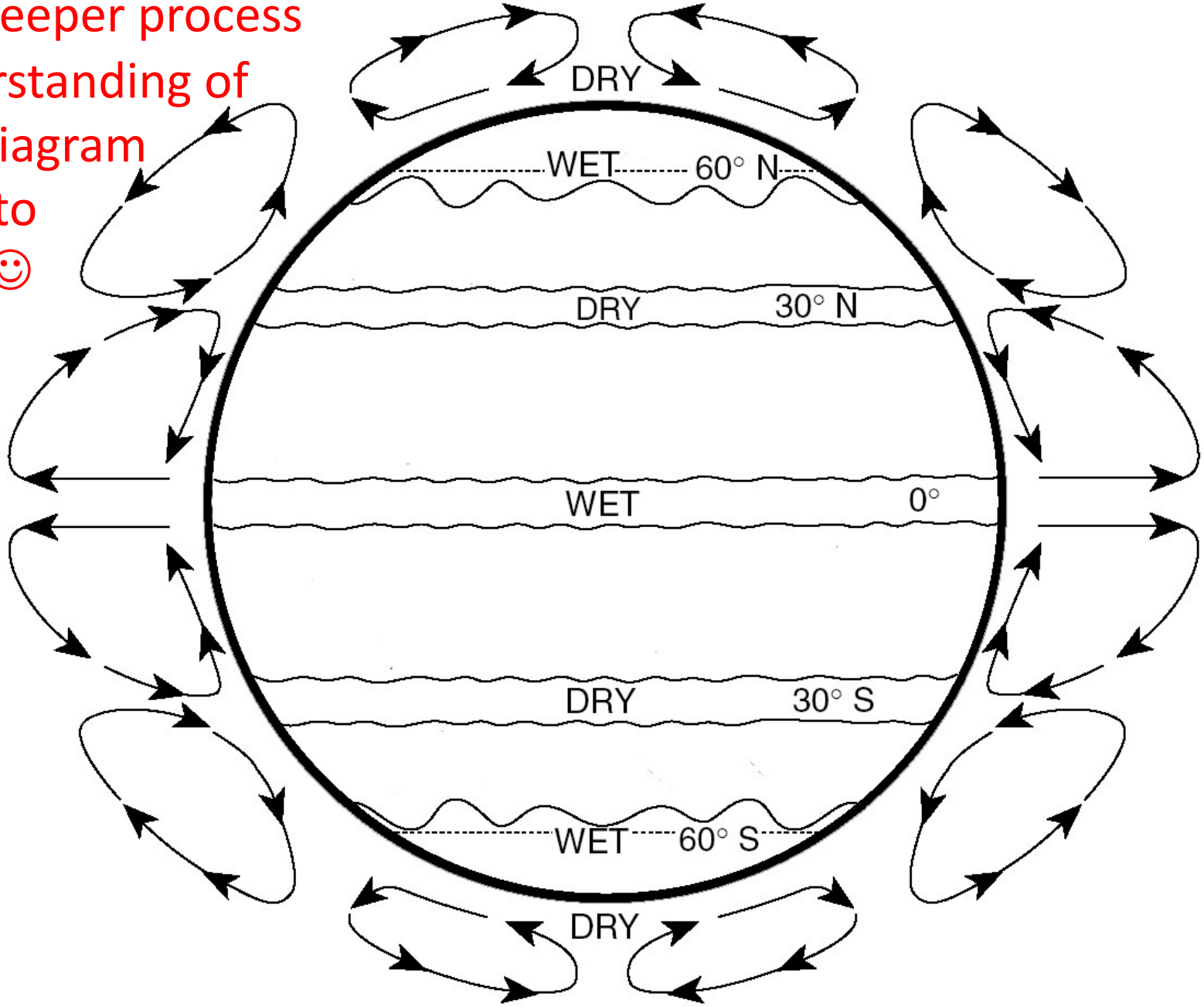


Keep in mind your reference tables do not contain details on temperature or precipitation as shown in this presentation – at least not *directly.*

For example, the "Planetary Wind & Moisture Belts…" diagram shows the following for convection and climate belts.

Convection & Moisture Belts

The deeper process understanding of this diagram is up to you! ☺



Convection & Moisture Belts: Part 2

(under construction…)

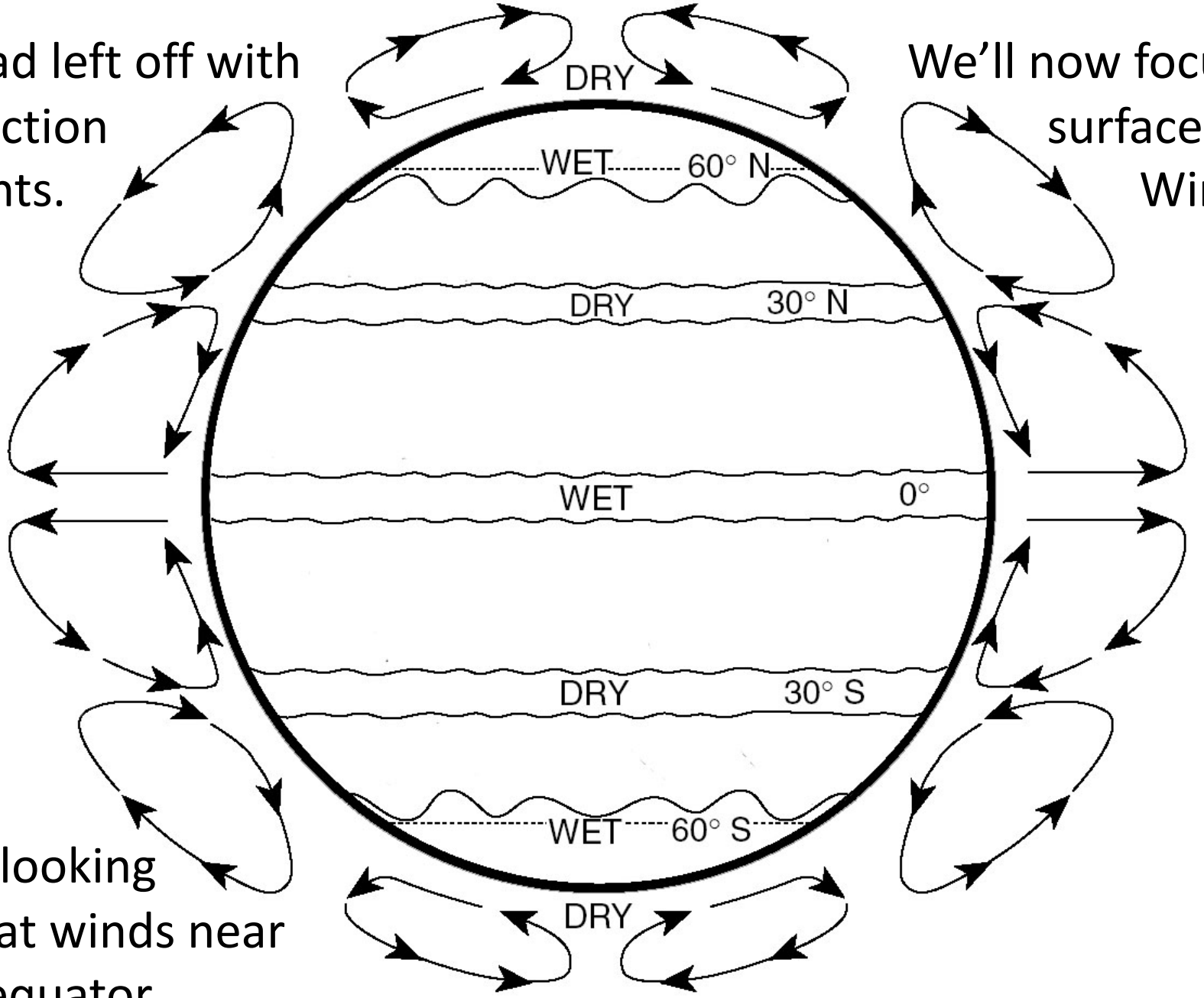
What causes air to deflect?

Why is the earth *not* made up of north and south winds only?

Convection & Moisture Belts

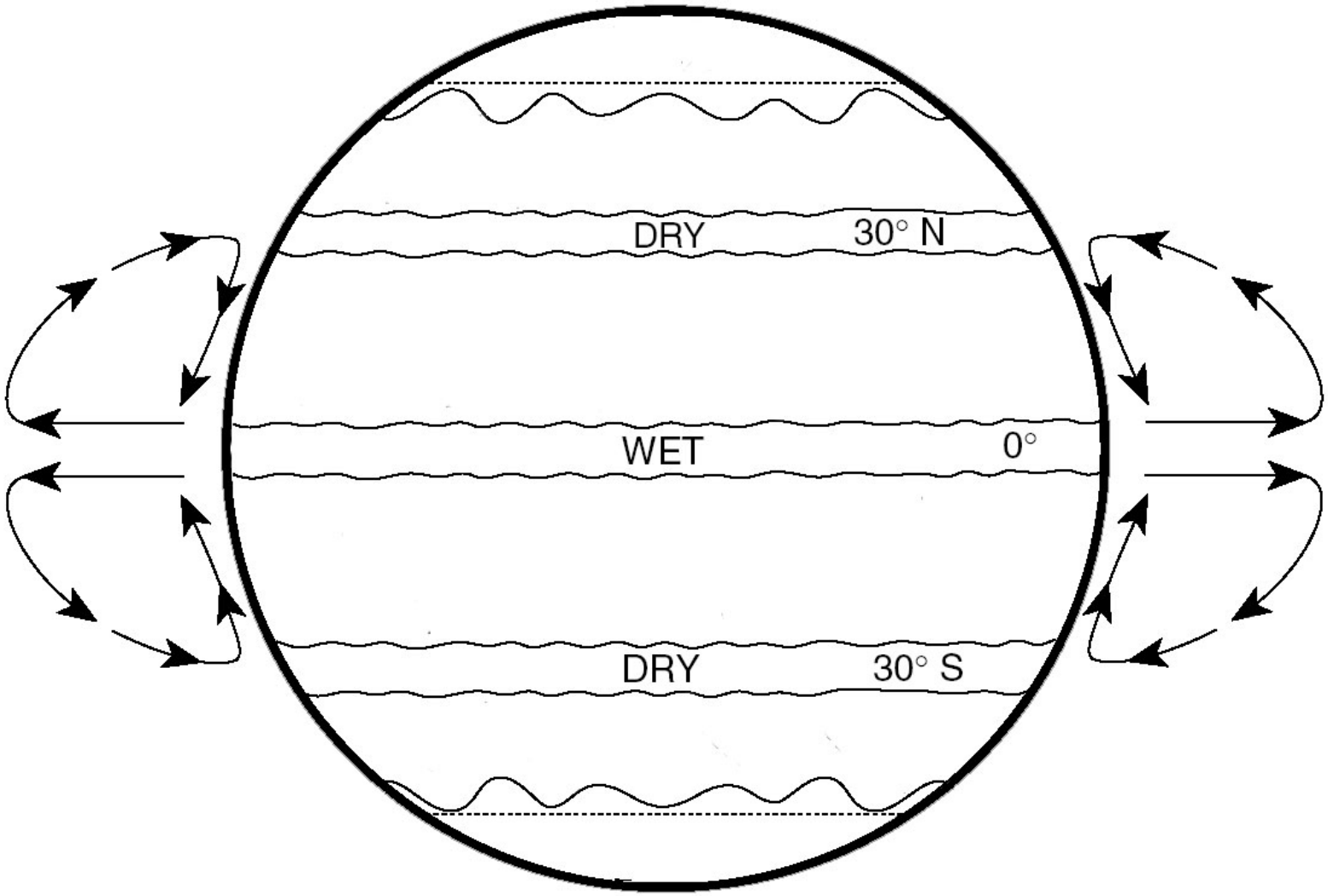
We had left off with convection currents.

We'll now focus on surface level Winds...



...By looking first at winds near the equator.

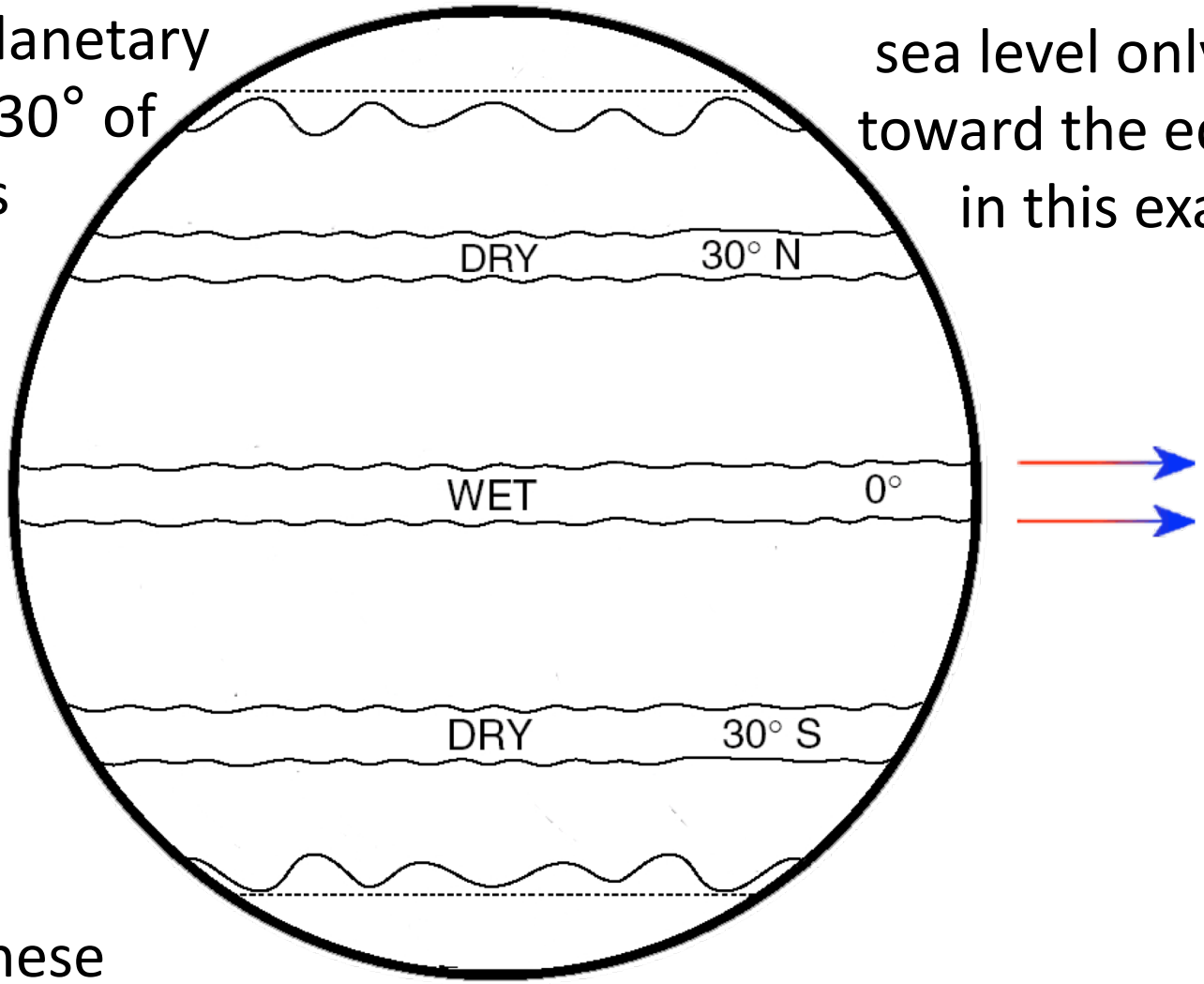
Convection & Moisture Belts



Convection & Moisture Belts

Convection of generalized planetary winds within 30° of the equator is shown here.

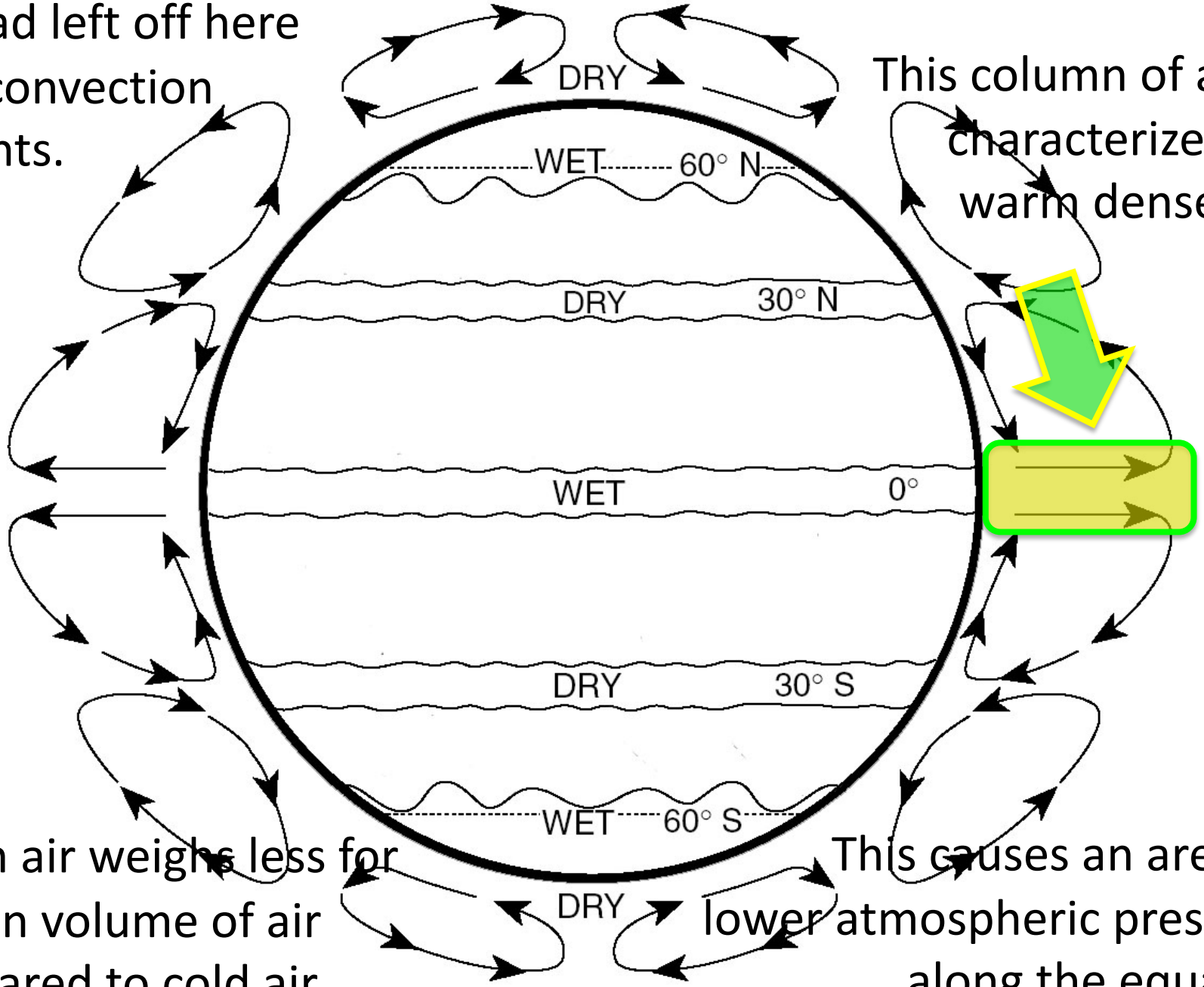
Note the winds near sea level only blow toward the equator in this example.



We'll start by focusing on these equatorial surface level northerly and southerly winds...

Convection & Moisture Belts

We had left off here with convection currents.



This column of air is characterized by warm dense air.

Warm air weighs less for a given volume of air compared to cold air.

This causes an area of lower atmospheric pressure along the equator.

Teacher Notes

Credits:

- http://epsc.wustl.edu/courses/epsc105a/files2/Animations_7/GlobalWind.html (convection animation within this presentation)

Other wind resources:

- http://earth.nullschool.net
- http://geog.uoregon.edu/envchange/clim_animations/
- **Click HERE to return to the start of this presentation.**