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?
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Let us focus on an observer at the equator & rotate the diagram 90° counter-clockwise.
Atmospheric Characteristics at the Equator (0° latitude):

- **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.
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Behavior of warm moist air at the equator:

• 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.
Behavior of warm moist air at the equator:

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Behavior of warm moist air at the equator:
• 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.
The model below is simplified, as it lacks gradual changes in air temperature and resulting precipitation patterns. Continue for further details...
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- Let’s start by examining the warm moist air rising vertically in the atmosphere.
- What happens to the mT air mass as it rises?
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- Refer to your Earth Science Reference Tables atmosphere layers diagram on p. 14 (see diagram below).
- Find the term “troposphere”.

![Diagram of atmospheric layers with troposphere highlighted]
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.
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- The diagram below will now reflect this gradual decrease in temperature as altitude increases.
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To review:

- 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.
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- How does the cooling of warm moist air relate to precipitation?
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- 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.
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1. Warm moist air rises.
2. The air expands and cools.
3. Cooling triggers condensation.
4. Continued cooling and condensation causes precipitation.
The cold dense air at higher altitudes has only one “escape route” – to diverge (spread out) and descend (sink) back toward earth’s surface.
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- The cold dense air at higher altitudes has only one “escape route” – to diverge (spread out) and descend (sink) back toward earth’s surface.
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- 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.
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- 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.
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- 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…
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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.
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- The **convection** shown below can also be referred to as two somewhat independent **convection cells**.
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.
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- The convection cell model shown below (focusing on the equator) can be rotated and viewed on a global scale...
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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.
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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.
The dry descending air at 30° North and South Latitude explains large desert regions found along this belt.
Convection & Moisture Belts

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

Again, note that this generalized climate information is noted here for you.
Convection & Moisture Belts

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

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

These divisions of 30° Latitude is also 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...
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Let us complete the convection cell pattern.
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Let us complete the convection cell pattern.
The alternating wet/dry climate belts also continue at 30° intervals.
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Creating evergreen forests at 60° North and South Latitude.

The alternating wet/dry climate belts also continue at 30° intervals.
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Creating evergreen forests at 60° North and South Latitude.

And, dry conditions at polar regions.

The alternating wet/dry climate belts also continue at 30° intervals.
Lastly, note the climate and latitude polar region information is also noted for you.
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.
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…
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.
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.
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.
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?
We had left off with convection currents. We’ll now focus on surface level winds...

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