Science for You: Weather

Week 2: Humidity and Relative Humidity

Introduction to humidity, part I: Mixing Ratio and Dew Point

To really understand weather, it's important to have a solid understanding of humidity. This first lecture is about mixing ratio and dew point – both different ways to describe "absolute humidity."

Dry gas composition of Earth's atmosphere:

- Nitrogen (N_2) 78%
  - Inert. The body needs nitrogen but doesn't get it from the atmosphere.
- Oxygen (O_2) 21%
  - Very reactive gas, needed for oxidation during respiration.
- Argon (Ar) 1%
  - Inert; heavy and dense. Used in insulated windows.
- Carbon Dioxide (CO_2) <.04%
  - Greenhouse gas
- Other molecules

Water vapor & humidity

- But don't forget water vapor! It's a "variable gas" ranging from ~0 to ~4% of the gasses in the air that isn't included in the "dry composition."

Mixing ratio is one way in which humidity is described.

- The mixing ratio is the number of grams of water vapor in a kilogram of air. More water means higher humidity.

M.R. = grams of water vapor (e.g., 3g/kg)
kg of air

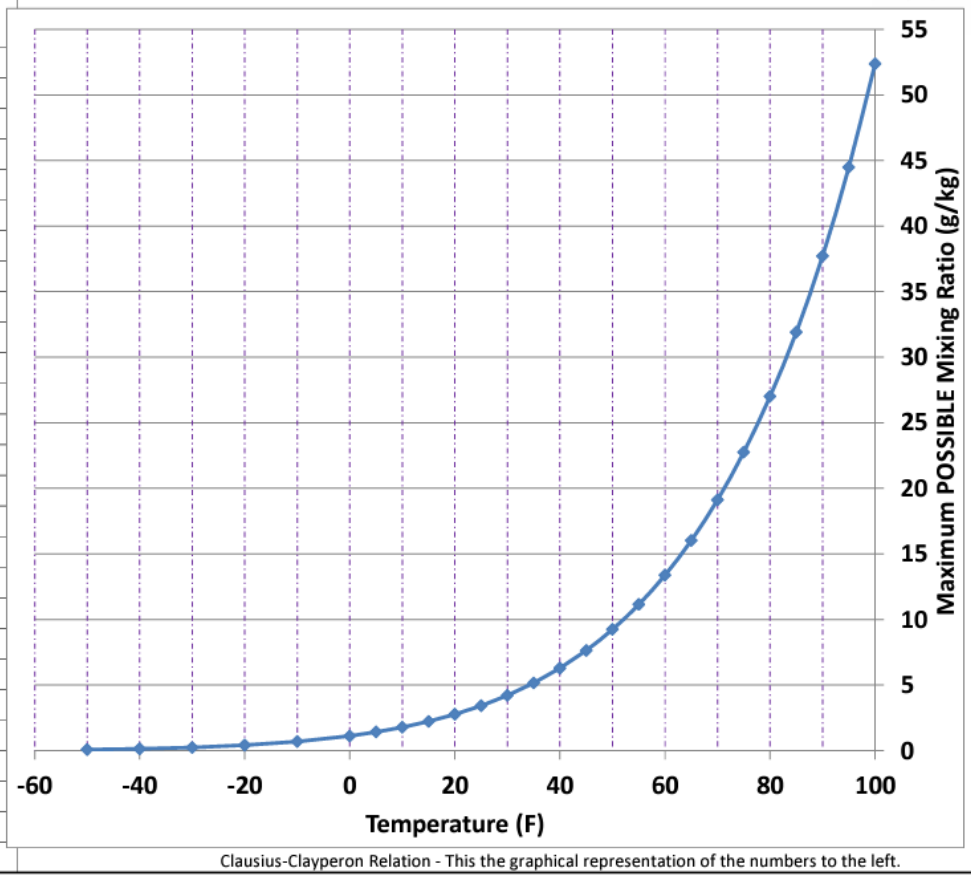
- A 1 cm cube of water weighs 1 gram (think of a sugar cube or a die)
  - 1 gram of water = 1 milliliter (1 ml)
- 1 cubic meter of air (at 1 mile altitude) is about 1 kg

○ (Sample problems and answers are available on the Weather page on the website www.tinyurl.com/OLLIscience4U)

- The temperature of the air dictates the maximum amount of water that could be in the atmosphere. The warmer the air, the more water that COULD exist in the vapor state.
- Cold air is dry air, even if it is fully saturated. Hot air can be either dry or humid.
- The following table (and graph) shows the maximum mixing ratio of the air at a particular temperature, but it could contain less than the maximum.

Values below are calculated for Albuquerque's altitude. If you live somewhere else, they would be slightly different.

Air Temperature (F)	Maximum Possible Mixing Ratio at this temperature (g/kg)
100	52.38
95	44.48
90	37.71
85	31.91
80	27.01
75	22.76
70	19.12
65	16.02
60	13.38
55	11.14
50	9.24
45	7.64
40	6.29
35	5.16
30	4.21
25	3.42
20	2.77
15	2.23
10	1.78
5	1.42
0	1.12
-10	0.69
-20	0.42
-30	0.24
-40	0.14
-50	0.08
-60	0.04



Clausius-Clayperon Relation - This the graphical representation of the numbers to the left.

- Note that if the air temperature goes up, so does the maximum possible mixing ratio. If the air temperature goes down, so does the maximum possible mixing ratio.
- **Earth.nullschool.net** is a website for visualizing weather features, including TPW (Total Precipitable Water) – how much water is in the atmosphere. This corresponds to the mixing ratio.
  - (Links and instructions for earth.nullschool.net are available on the Weather page on the website www.tinyurl.com/OLLIscience4U)

Dew point is another way in which humidity is reported.

- Air can contain a certain amount of water vapor before it becomes **saturated** and can no longer hold any more water vapor.
- The temperature at which the air becomes saturated with water vapor is called the **"dew point temperature"** (often just called "dew point").
- Cooling the air past its saturation point results in **condensation** – turning water vapor into liquid water. This can result in dew (or frost).
- Air that has less water vapor (lower humidity) has a lower dew point.
  - Low dew point = less water vapor = dry air
  - High dew point = more water vapor = humid air
- Wind direction is an important factor in changes in the dew point (especially in New Mexico)
  - If the wind blows in cold dry air from the north, the dew point will be low.
  - If the wind blows in warm humid air from the southeast, the dew point will be high.

Introduction to humidity, part II: Relative Humidity

Relative Humidity is the most common way that humidity is reported in weather reports, but few people understand what it is. This lecture describes how relative humidity is calculated and the environmental factors that can change it.

Review:

- Mixing Ratio is one way to describe humidity. It is expressed as grams of water per kilogram of air.
- Dew Point is another way to describe humidity. It is the temperature at which the air would be saturated.
- What changes the dew point temperature or mixing ratio?
    - If water is added to the air, both mixing ratio and dew point increase.
    - If water is removed from the air, both mixing ratio and dew point decrease.
    - A change in wind direction will often change dew point and mixing ratio because it brings in colder, drier air or warmer, more humid air.
- If the temperature cools below the dew point, the dew point decreases if the temperature decreases. This is because water has condensed out of the air and the dew point will therefore decrease.
    - The dew point can never be higher than the temperature!!

Relative humidity is the most common way that humidity is reported, but it is also the most confusing and least understood by the public.

- Saying that the relative humidity is 35% does not mean that the amount of water vapor in the air is 35%. Remember, the amount of water vapor is between 0 and ~4% of the atmosphere.

$$\text{Relative humidity} = \frac{\text{Current mixing ratio}}{\text{Maximum possible mixing ratio at the current temperature}} \times 100$$

- Relative humidity tells you how close the air is to saturation. 100% relative humidity = saturated air, meaning it cannot hold any more water vapor.
- When relative humidity increases, it **does not mean** that the air got more humid. It usually means that the temperature went down. (It could also mean that something added more water to the air, like having the sprinklers come on.)

More facts about relative humidity

- When the temperature = the dew point, then relative humidity is 100%.
- Inside a cloud, the relative humidity is 100%.
- You can't have relative humidity over 100%.
- The relative humidity usually cycles over 24 hours, whereas dew point and mixing ratio usually do not.
- Relative humidity is related to human comfort/discomfort:
    - Hot day + high RH = misery
    - Hot day + low RH = desiccation
    - Cold day + high RH = feels colder
- Heat index shows the apparent temperature at different air temperatures and relative humidity levels.

Air Temp.	70°	75°	80°	85°	90°	95°	100°	105°	110°
Relative Humidity	Apparent Temperature (Degrees Fahrenheit) →								
0%	64°	69°	73°	78°	83°	87°	91°	95°	99°
10%	65°	70°	75°	80°	85°	90°	95°	100°	105°
20%	66°	72°	77°	82°	87°	93°	99°	105°	112°
30%	67°	73°	78°	84°	90°	96°	104°	113°	123°
40%	68°	74°	79°	86°	93°	101°	110°	122°	137°
50%	69°	75°	81°	88°	96°	107°	120°	135°	150°
60%	70°	76°	82°	90°	100°	114°	132°	149°	
70%	70°	77°	85°	93°	106°	124°	144°		
80%	71°	78°	86°	97°	113°	136°	157°		
90%	71°	79°	88°	102°	122°	150°	170°		
100%	72°	80°	91°	108°	133°	166°			

- Relative humidity is related to fire danger: low RH = high fire danger.
- Relative humidity is related to evaporation rate: low RH = quick evaporation.