Earth Science Workshop

How Humidity Works

Specific Humidity

Specific humidity is simply a measurement of the total water content of a parcel of air that has a known mass.

Let's say that you have a sample of air that weighs 10kg, and when you extract all the water out of it, you find that it has 20g of water in the sample. The specific humidity of the parcel of air would be 2g/kg. All we are doing is diving the grams of water vapor by the kg of air. In our scenario above, even though there are 10kg of air, the water vapor is still distributed roughly evenly throughout the air, which leaves us with our 2g/kg.

Questions

1. If a parcel of air has a mass of 20kg and the mass of water vapor extracted was 100g total, what would be the specific humidity of the parcel of air?
2. If we know the specific humidity of a parcel of air is 1g/kg, how many kg of air is the parcel if we know that there are 3g of water vapor in it?

Relative Humidity

Air can only hold so much water at a time, you cannot keep adding water vapor endlessly. The amount of water that air can hold is directly related to the temperature of the air. Warmer air can hold more water vapor than colder air can. Let's say that air that is 20 degrees can hold 14g of water vapor per kg of air. It has a max capacity of 14g/kg. Now, air that is 25 degrees can hold 20g/kg and air that is 15 degrees can hold 10g/kg. We can see that as the air temperature rises, so too does the capacity.

Relative humidity is a measurement of how much water vapor is in the air compared with how much there could be. We call air that is at its maximum capacity of water fully saturated air. Saturated air cannot hold any more water. So, if the air was 25 degrees, it has a capacity of 20g/kg. If the air has a specific humidity of 10g/kg, then the relative humidity would be 50%. To find this number, we take how much water vapor we have and divide it by how much we could have, in this case 10g/kg / 20g/kg. This gives us 0.5, which we multiply by 100 to give us 50%.

Questions

3. If the air at 20 degrees has a capacity of 14g/kg, and the amount of water vapor in it is 12g/kg, what is its relative humidity?
4. If the relative humidity is 80%, and we know that the maximum capacity of the air is 10g/kg, how much water vapor is actually in the air?

When we use humidity in our daily lives, it is almost always relative humidity because that is what is the most useful. Knowing how close to being saturated the air is tells us how likely it is to rain and how humid we will perceive the air to be. Rainfall starts when humidity tries to exceed 100%, so knowing how close it is to that mark tells us when the rain is likely to come. One interesting feature of relative humidity is that because it is in reference to how much water vapor the air could hold, the relative humidity is directly affected by the air temperature and can change. To illustrate this point, let's assume that there is 10g/kg of water vapor in a parcel of air. If the air temperature is 25 degrees, then the capacity of the air would be 20g/kg and the relative humidity would be 50%. If the air was cooled down and dropped to 15 degrees, then the capacity of the air would also drop to 10g/kg and the relative humidity would now be 100%, even though the total water vapor in the air stayed at 10g/kg.

This might be confusing, but think about a typical day in Florida. The morning usually has very high humidity, upwards of 90%. The morning is also usually the coolest part of the day because the sun hasn't warmed up the land yet. As the day progresses, the temperature increases, but the air doesn't usually feel as heavy because the relative humidity has dropped because the capacity of the air has risen along with the temperature. If a rainstorm comes through, then the temperature usually drops. Since rain is just 100% or more humidity, after the rain passes the air starts to feel heavy again due to the increase in relative humidity, but the air is also cooler. In fact, quickly cooling the air and forcing the relative humidity above 100% can wring the water out of the air and make it rain. So, the warmer the air, the higher the water vapor capacity. The colder the air, the lower the capacity. This change affects the relative humidity without actually adding or removing any water vapor.

Questions

5. If the relative humidity goes up, but no water vapor was added to the air, did the temperature go up or down?
6. If the relative humidity is 90% and the temperature of the air drops drastically, what is likely to happen?

We use a device called a hygrometer to measure humidity. The easiest hygrometer to use is called a sling psychometer. A sling psychrometer has two thermometers, one with a dry bulb, one with a bulb that has a wick on the end that we wet. Then we sling the psychrometer around for a minute or two, then we look at the temperatures. The wet bulb temperature should have dropped due to the evaporation of the water from the wick. The higher the temperature drop, the more evaporation that happened. Water can only evaporate if there is enough capacity in the air to hold more water vapor, so high evaporation means that the air has less water vapor and is less humid, and low evaporation means that the air is close to being full and has high humidity.

By looking at the normal air temperature on the dry bulb, which should remain consistent, and then figuring out the depression (dry bulb – wet bulb = depression), we can find the relative humidity on a psychrometric chart. A basic psychrometric chart can be found below and all we have to do is to find our dry bulb temperature on the Y axis, find our depression on the X axis, and then find where they intersect on the chart. For instance, if the dry bulb temperature is 32 degrees and the depression is 10, then the relative humidity would be 41%.

Questions

7. If the depression is high, then a lot of water evaporated. Is the humidity high or low?
8. If the humidity is 91% and the dry bulb temperature is 20 degrees, what is the depression?

D.B.	Depression of W.B.																			
Temp.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
0°C	81	63	45	28	11															
2°C	83	67	51	36	20	6														
4°C	85	70	56	42	27	14	3													
6°C	86	72	59	46	35	22	10													
8°C	87	74	62	51	39	28	17	6												
10°C	88	76	65	54	43	38	24	13	4											
12°C	88	78	67	57	48	38	28	19	10	2										
14°C	89	79	69	60	50	41	33	25	16	8	1									
16°C	90	80	71	62	54	45	37	29	21	14	7	1								
18°C	91	81	72	64	56	48	40	33	26	19	12	6	0							
20°C	91	82	74	66	58	51	44	36	30	23	17	11	5	0						
22°C	92	83	75	68	60	53	46	40	33	27	21	15	10	4	0					
24°C	92	84	76	69	62	55	49	42	36	30	25	20	14	9	4	0				
26°C	92	85	77	70	64	57	51	45	39	34	28	23	18	13	9	5				
28°C	93	86	78	71	65	59	53	45	42	36	31	26	21	17	12	8	4			
30°C	93	86	79	72	66	61	55	49	44	39	34	29	25	20	16	12	8	4		
32°C	93	86	80	73	68	62	56	51	46	41	36	32	27	22	19	14	11	8	4	
34°C	93	86	81	74	69	63	58	52	48	43	38	34	30	26	22	18	14	11	8	5
36°C	94	87	81	75	69	64	59	54	50	44	40	36	32	28	24	21	17	13	10	7
38°C	94	87	82	76	70	66	60	55	51	46	42	38	34	30	26	23	20	16	13	10
40°C	94	89	82	76	71	67	61	57	52	48	44	40	36	33	29	25	22	19	16	13

Relative Humidity

Answers

1. 5g/kg.
2. 3 kg of air.
3. 85% or 86%.
4. 8g of water vapor.
5. The temperature went down.
6. It will reach 100% and then rain.
7. Low.
8. 1.