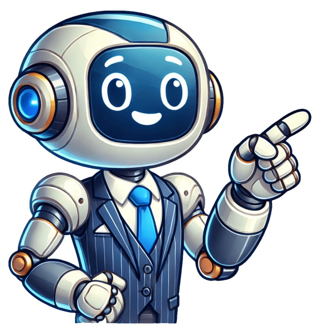
I'm not a robot



The calculation of the mixing ratio is fundamental in meteorology and environmental engineering. It quantifies the mass of water vapor relative to dry air in a given volume.This article explores detailed formulas, common values, and real-world applications of mixing ratio calculations. It serves as a comprehensive technical guide for experts and practitioners.Calculate the mixing ratio given temperature, pressure, and relative humidity.Determine the mixing ratio from vapor pressure and atmospheric pressure.Find the mixing ratio for saturated air at a specific temperature.Compute the mixing ratio change during an adiabatic process.Extensive Tables of Common Mixing Ratio ValuesMixing ratio values vary with temperature and pressure, especially in atmospheric conditions. Below is a detailed table showing typical mixing ratios (in g/kg) for saturated air at various temperatures and pressures.Temperature (C)Saturation Vapor Pressure (hPa)Mixing Ratio at 1000 hPa (g/kg)Mixing Ratio at 900 hPa (g/kg)Mixing Ratio at 800 hPa (g/kg)Mixing Ratio at 700 hPa (g/kg)Mixing Ratio at 600 hPa (g/kg)06.114.855.396.006.717.5658.726.907.678.549.5310.681012.289.4010.4611.6513.0014.581517.0512.9014.3516.0017.8520.002023.3717.3019.2021.5024.0026.902531.6723.0025.5028.6032.0035.803042.4330.4033.7037.9042.5047.603556.2339.8044.2049.8055.8062.60The saturation vapor pressure values are derived from the Clausius-Clapeyron equation and represent the maximum water vapor pressure at a given temperature. The mixing ratio values are calculated assuming saturation at the specified atmospheric pressures.Fundamental Formulas for the Calculation of the Mixing RatioThe mixing ratio (w) is defined as the mass of water vapor (m_v) per unit mass of dry air (m_d). It is commonly expressed in grams of water vapor per kilogram of dry air (g/kg).Mathematically, the mixing ratio is given by:However, in atmospheric science, it is more practical to calculate the mixing ratio from vapor pressure and atmospheric pressure using the following formula:w = 0.622 (e / (P e))w: Mixing ratio (kg water vapor per kg dry air)e: Partial pressure of water vapor (vapor pressure) in hPa or PaP: Total atmospheric pressure in hPa or Pa0.622: Ratio of the molecular weight of water vapor (18.016 g/mol) to dry air (28.966 g/mol)It is important to ensure that the units of pressure are consistent. Typically, both e and P are expressed in hPa (hectopascals) or Pa (pascals).Calculating Vapor Pressure (e)Vapor pressure can be calculated from temperature and relative humidity (RH) using the formula:RH: Relative humidity in percentage (%)es: Saturation vapor pressure at temperature TThe saturation vapor pressure es can be estimated using the Tetens formula:es = 6.112 exp((17.67 T) / (T + 243.5))T: Temperature in Cexp: Exponential functionThis formula provides es in hPa.Temperature (T): Usually between -40C and 50C in atmospheric applications.Atmospheric Pressure (P): Standard sea level pressure is 1013.25 hPa; varies with altitude.Relative Humidity (RH): Ranges from 0% (dry air) to 100% (saturated air).Mixing Ratio (w): Typically ranges from near 0 g/kg in dry air to over 30 g/kg in humid tropical air.For completeness, the following related formulas are essential in advanced calculations involving the mixing ratio.Specific Humidity (q)Specific humidity is the ratio of the mass of water vapor to the total mass of moist air (dry air + water vapor):Where q is dimensionless (kg/kg).Relative Humidity from Mixing RatioGiven the mixing ratio, relative humidity can be calculated as:RH = 100 (w P) / (0.622 + w) / esThis formula is useful for converting between humidity parameters.Real-World Applications and Detailed ExamplesExample 1: Calculating Mixing Ratio from Temperature, Pressure, and Relative HumidityConsider an atmospheric condition where the temperature is 25C, atmospheric pressure is 1000 hPa, and relative humidity is 60%. Calculate the mixing ratio.Step 1: Calculate saturation vapor pressure es using Tetens formula:es = 6.112 exp((17.67 25) / (25 + 243.5))= 6.112 exp(441.75 / 268.5)= 6.112 exp(1.645) 6.112 5.18 31.67 hPaStep 2: Calculate actual vapor pressure e:e = (60 / 100) 31.67 = 0.6 31.67 = 19.00 hPaStep 3: Calculate mixing ratio w:w = 0.622 (19.00 / (1000 19.00)) = 0.622 (19.00 / 981) 0.622 0.01937 0.01205 kg/kgConverting to g/kg:w = 0.01205 1000 = 12.05 g/kgResult: The mixing ratio is approximately 12.05 g/kg.Example 2: Determining Mixing Ratio at High AltitudeAt an altitude where atmospheric pressure is 700 hPa, temperature is 10C, and the air is saturated (RH = 100%), calculate the mixing ratio.Step 1: Calculate saturation vapor pressure es:es = 6.112 exp((17.67 10) / (10 + 243.5))= 6.112 exp(176.7 / 253.5)= 6.112 exp(0.697) 6.112 2.008 12.28 hPaStep 2: Since RH = 100%, e = es = 12.28 hPaStep 3: Calculate mixing ratio w:w = 0.622 (12.28 / (700 12.28)) = 0.622 (12.28 / 687.72) 0.622 0.01785 0.0111 kg/kgConverting to g/kg:w = 0.0111 1000 = 11.1 g/kgResult: The mixing ratio at 700 hPa and 10C saturated air is approximately 11.1 g/kg.While the above formulas and examples cover standard atmospheric conditions, several factors can influence the accuracy and applicability of mixing ratio calculations in specialized contexts.Non-Standard Atmospheric Composition: Variations in dry air composition or presence of pollutants can slightly alter molecular weights, affecting the 0.622 constant.High Altitude and Low Pressure: At very low pressures, assumptions of ideal gas behavior may fail, requiring corrections.Temperature Extremes: At temperatures below freezing, phase changes and supercooled water vapor complicate saturation vapor pressure calculations.Dynamic Atmospheric Processes: Adiabatic cooling/heating, mixing, and condensation processes require time-dependent modeling of mixing ratio changes.For these cases, more sophisticated thermodynamic models and numerical methods are employed, often integrated into atmospheric simulation software.Useful External Resources for Further StudyThe mixing ratio is a critical parameter quantifying water vapor content relative to dry air.It is calculated primarily using vapor pressure and atmospheric pressure, with the molecular weight ratio constant 0.622.Saturation vapor pressure is temperature-dependent and can be estimated using the Tetens formula.Mixing ratio values vary significantly with temperature, pressure, and humidity, as shown in extensive tables.Real-world applications include weather forecasting, climate modeling, and environmental monitoring.Advanced scenarios require corrections for non-ideal conditions and dynamic atmospheric processes.Mastering the calculation of the mixing ratio enables precise understanding and prediction of atmospheric moisture behavior, essential for meteorologists, environmental engineers, and climate scientists. The mixing ratio is calculated using the formula: MR = 6.11 10^(7.5 DP / (237.7 + DP))SMR = 6.11 10^(7.5 T / (237.7 + T)) The Mixing Ratio Calculator is a versatile tool used in meteorology, chemistry, and industrial applications to calculate the ratio of a substance (e.g., water vapor) mixed with dry air. It is particularly useful for determining atmospheric conditions, chemical dilutions, or product mixes. Formula Mixing Ratio (MR) = 6.11 10^(7.5 DP / (237.7 + DP))Saturation Mixing Ratio (SMR) = 6.11 10^(7.5 T / (237.7 + T))VariableDescriptionMRMixing Ratio (g/kg or other units as required)SMRSaturation Mixing RatioDPDew Point Temperature (C)TAir Temperature (C)Solved CalculationsExample 1: Calculate Mixing RatioStepValueDew Point (DP)20CMR = 6.11 10^(7.5 20 / (237.7 + 20))17.3 g/kg Example 2: Calculate Saturation Mixing RatioStepValueAir Temperature (T)25CSMR = 6.11 10^(7.5 25 / (237.7 + 25))23.1 g/kgWhat is Mixing Ratio ?A Mixing Ratio Calculator is a versatile tool that simplifies the process of determining the correct proportions for mixing various substances. It is widely used across different fields, such as construction, automotive maintenance, painting, meteorology, and more.The calculator ensures precision when mixing materials like fuel, paint, concrete, or chemical solutions by offering quick and accurate results.For example, this tool helps you calculate common ratios, such as 2-stroke fuel mixes or paint mixing ratios, based on weight or volume. It is also handy for specific applications, like dilution ratio calculators for liquids or determining the saturation mixing ratio in meteorology.READ ALSO : Fixed Cost CalculatorTools like the epoxy mixing ratio calculator and concrete mixing ratio calculator provide tailored solutions for specialized needs.By reducing guesswork and ensuring accuracy, the Mixing Ratio Calculator saves time and minimizes waste, making it an indispensable resource for both professionals and hobbyists.Final Words:In essence, the Mixing Ratio Calculator is a reliable and efficient tool for precise mixing. It streamlines calculations, enhances accuracy, and supports a wide range of applications, ensuring the perfect mix every time. Related Resources: calculators Thermodynamics Vaporization Rate (Qm, mass time) from a Liquid Surface Equation and Calculator The rate of evaporation depends only on the surface area of the liquid and is essentially constant . The rate of condensation depends on the number of molecules in the vapor phase and increases steadily until it equals the rate of evaporation. Eq. 1 Qm = [M K As Psat] / (Rg TL) Where: M = molecular weight of volatile substance K = mass-transfer coefficient As = area of liquid surface Psat = saturation vapor pressure of the pure liquid at TL Rg = ideal gas constant TL = absolute temperature of the liquid Reference The Fundamentals of Engineering (FE) Handbook, 2020 Related Steven WoodingSteven Wooding is a physicist by training with a degree from the University of Surrey specializing in nuclear physics. He loves data analysis and computer programming. He has worked on exciting projects such as environmentally aware radar, using genetic algorithms to tune radar, and building the UK vaccine queue calculator. Steve is now the Editorial Quality Assurance Coordinator here at Omni Calculator, making sure every calculator meets the standards our users expect. In his spare time, he enjoys cycling, photography, wildlife watching, and long walks. See full profileCheck our editorial policyDominik Czernia, PhDDominik CzerniaPhD, Institute of Nuclear Physics PANDominik Czernia, PhD, is a physicist at the Institute of Nuclear Physics in Krakw, specializing in condensed matter physics with a focus on molecular magnetism. He has led several national research projects, pioneering innovative approaches to novel materials for high technology. Passionate about making science accessible, Dominik has created various calculators, mostly in physics and math categories. In his free time, he enjoys family walks, city explorations, mountain hiking, and traveling everywhere by bike. See full profileCheck our editorial policy and Rijk de WetRijk de WetA self-described nerd, Rijk is passionate about making a positive difference in the lives of Omnis users. Hes an avid programmer, musician, and board game player, and both his calculators and side-projects reflect his hobbies. He believes that any problem can be solved with the right set of equations and a few lines of code. See full profileCheck our editorial policy128 people find this calculator helpfulTable of contentsIf you have ever wondered how fast water evaporates and what affects the speed of evaporation, then the evaporation rate calculator is perfect for you.The following article delves into the theory behind evaporation rate calculations and provides practical examples using the evaporation rate calculator. It covers:How to use the evaporation rate calculator;How to calculate evaporation rates;The daily evaporation rate formula; andHow fast does pool water evaporate?OK, let's dive in! (As long as all the water hasn't evaporated.)Let's see how you can use our evaporation rate calculator to see how fast your garden pond is going to evaporate into thin air.First, we need to know the surface area of your pond let's say you have a 20 square-foot pond (1.86 m). The evaporation rate is proportional to the surface area.Next, enter the average air speed in your garden. You can get this from today's weather report. Today, it says there is a 5 mph light breeze (8 km/h). The stronger the wind, the faster the evaporation rate.The calculator can accept two sets of inputs: either temperature and relative humidity or the current and maximum humidity ratios. The first set of data is easy to look up, so let's go with using temperature and humidity for now.Looking again at today's weather report, you see that it's 68 F (20 C) with a relative humidity of 70%. Nice And that's it. We have answered what the evaporation rate is: 1.2 lb per hour (0.55 kg per hour). Since 1 liter of water weighs approximately 1 kilogram (see water density calculator), that's 0.55 liters per hour (0.15 US gallons per hour).That might seem more than you expected, but it will be less at night when it is colder and more humid. For example, for 50 F (10 C) and 90% relative humidity, the evaporation rate is only 0.2 lb/hr (0.1 kg/hr).If you know the current and maximum humidity ratios, you can open up the last section of the calculator and enter these values to obtain a result for the evaporation rate.Another application of the calculator is as a pool evaporation rate calculator, so you know how much to top up your pool in the summer. You might also find our pool volume calculator useful for calculating how much water is in your pool to begin with.The evaporation rate of water can be calculated using the following formula:gh= (25+19v)A(XsX)\footnotesize g_\mathrm h = (25\! +\! 19\!\times\! v)\!\times\! A \!\times\! (X_\mathrm s\! -\! X)gh=(25+19v)A(XsX)where:ghg_\mathrm hgh Evaporation rate in kg per hour;vvv Velocity of air above the surface (m/s);AAA Surface area of the body of water (m);XsX_\mathrm sXs Maximum humidity ratio of saturated air (given the same temperature as the water's surface); andXXX Current humidity ratio of the air (kg/kg).The last two variables measure how much water the air can "hold" as water vapor. The current humidity ratio is the weight of water per unit weight of air (for example, how many kilograms of water vapor in a kilogram of air). This is also known as the specific humidity.The maximum humidity ratio is the maximum amount of water the air can hold before it condenses out into liquid water (e.g., it starts raining). This value changes dramatically with air temperature, but we can fit an empirical formula to the data for a typical temperature range (030 C, 3286F):Xs=3.733103+3.2104T+3106T2+4107T3\footnotesize\begin{split}X_s = 3.733\! \times\! 10^{-3} + 3.2\! \times\! 10^{-4} \! \times \! T\ +\\ 3\! \times \! 10^{-6}\! \times \! T^2 + 4\! \times \! 10^{-7} \! \times \! T^3\end{split}Xs=3.733103+3.2104T+3106T2+4107T3where TTT is the air temperature at the water's surface in degrees Celsius.Using this formula allows you to enter temperature instead of having to know the maximum humidity ratio. However, for temperatures below 0 C (32 F) and above 30 C (86 F), its accuracy can not be guaranteed, because the formula is derived from maximum humidity ratio data given in this psychrometic chart at 100% relative humidity.The remaining input, relative humidity, measures what percentage of the maximum humidity is the current humidity.The evaporation rate formula given above is for the amount of water that evaporates in an hour. To obtain the daily evaporation rate, we can simply multiply by the 24 hours in a day:gd=24(25+19vd)A(XsdXd)\footnotesize\begin{aligned}g_\mathrm d =&\ 24\! \times\! (25\! +\! 19\!\times\! v_\mathrm{\ \overline{d}}) \\&\ \times A\! \times\! (X_\mathrm{s\overline{d}}\! -\! X_\mathrm{\overline{d}})\end{aligned}gd=24(25+19vd)A(XsdXd)Note that you now need to use the average wind velocity vdv_\mathrm{\ \overline{d}}vd, maximum humidity ratio XsdX_\mathrm{s\overline{d}}Xsd, and current humidity ratio XdX_\mathrm{\overline{d}}Xd over a day to get an accurate result.In the calculator, you can change the second unit of the evaporation rate from per hour to per day. Then, make sure you use the daily average air speed, temperature, and relative humidity to find out what evaporation rate is per 24 hours.Water is made up of molecules that move at different speeds, and some have enough energy to overcome the intermolecular forces of the other water molecules and escape the water's surface. The water molecule is then floating in the air, where it is now a gas called water vapor.To calculate the evaporation rate of a body of water, follow these steps:Multiply the wind speed (m/s) by 19 and add 25.Multiply by the surface area of the water (m).Multiply by the maximum humidity ratio subtracted from the current humidity ratio (kg/kg).You'll then have the water's evaporation rate in kilograms per hour.Around 22 pounds of water an hour (10 kg/h). This assumes a pool size of 30 by 15 feet, a light breeze of 3 mph, a temperature of 82 F, and 80% relative humidity. If these conditions lasted all afternoon (6 hours), you'll have to top up your pool by around 16 gallons (60 liters).To see how fast your pool's water will evaporate, visit Omni Calculator's evaporation rate calculator.The main environmental factor when it comes to the evaporation rate of water is relative humidity. If the air is already saturated with water, then no more water can evaporate into it without immediately falling back into the water.Wind across the surface of the water is also significant, as it brings in fresh, dry air from the environment. With no wind, the relative humidity close to the water's surface will increase and slow the evaporation rate.Did we solve your problem today?Check out 45 similar thermodynamics and heat calculators Evaporation of water from a water surface - like an open tank, a swimming pool or similar - depends on water temperature, air temperature, air humidity and air velocity above the water surface.The amount of evaporated water can be expressed as: gs = A (xs - x) / 3600 (1) or gh = A (xs - x) where gs = amount of evaporated water per second (kg/s) gh = amount of evaporated water per hour (kg/h) = (25 + 19 v) = evaporation coefficient (kg/m2h) v = velocity of air above the water surface (m/s) A = water surface area (m2) xs = maximum humidity ratio of saturated air at the same temperature as the water surface (kg/kg) (kg H2O in kg Dry Air) x = humidity ratio air (kg/kg) (kg H2O in kg Dry Air) Note! The units for don't match since the this is an empirical equation - a result of experience and experiments.Required Heat SupplyMost of the heat or energy required for the evaporation is taken from the water itself. To maintain the water temperature - heat must be supplied to the water.Required heat to cover evaporation can be calculated as q = hwe gs (2) where q = heat supplied (kJ/s (kW)) hwe = evaporation heat of water (kJ/kg) Example - Evaporated Water from a Swimming PoolThere is a 50 m x 20 m swimming pool with water temperature 20 oC. The maximum saturation humidity ratio in the air above the water surface is 0.014659 kg/kg. With air temperature 25 oC and 50% relative humidity the humidity ratio in the air is 0.0098 kg/kg - check Mollier diagram.With air velocity above the water surface 0.5 m/s the evaporation coefficient can be calculated as = (25 + 19 (0.5 m/s)) = 34.5 kg/m2h The area of the swimming pool can be calculated as A = (50 m) (20 m) = 1000 m2The evaporation from the surface can be calculated as gs = (34.5 kg/m2h) (1000 m2) ((0.014659 kg/kg) - (0.0098kg/kg)) / 3600 = 0.047 kg/s The evaporation heat (enthalpy) of water at temperature at 20 oC is 2454 kJ/kg . The heat supply required to maintain the temperature of the water in the swimming pool can be calculated as q = (2454 kJ/kg) (0.047 kg/s) = 115.3 kW The energy loss and required heat supply can be reduced byreducing the air velocity above the water surface - limited effectreducing the size of the pool - not really practicalreducing the water temperature - not a comfort solutionreducing the air temperature - not a comfort solutionincrease the moisture content in the air - may increase the condensation and damage of the building constructions for indoor poolsremove the wet surface - possible with plastic blankets on the water surface outside operation time. Very effective and commonly used Note! - during operation time the activity in a swimming pool may increase the evaporation of water and the required heat supply dramatically.To reduce the energy consumption and to avoid moisture damages in building constructions it is common to use heat recycling devices with heat pumps moving latent heat from the air to the water in the swimming pool.Water Surface Evaporation Calculator The drying force of air depends on the air moisture holding capacity and the water surface to air evaporation capacity. The mass of water vapor present in moist air - to the mass of dry air. The moisture holding capacity of air increases with temperature. Convert between units of area. Maximum cooling tower efficiency is limited by the cooling air wet-bulb temperature. Evaporative cooling tutorial. Due to evaporation the heat loss from an open water tank like a swimming pool may be considerable. Online calculator, figures and tables with melting points of ice to water at pressures ranging from 0 to 29000 psia (0 to 2000 bara). Temperature given as C, F, K and R. Calculate sensible and latent heat from persons, lights, electric equipment, machines, evaporation from water surfaces, polluting fluids and miscellaneous loads. Latent heat of vaporization for fluids like alcohol, ether, nitrogen, water and more. Boiling temperatures for common liquids and gases - acetone, butane, propane and more. Sensible and latent heat of moist air. The Mollier diagram is a graphic representation of the relationship between air temperature, moisture content and enthalpy - and is a basic design tool for building engineers and designers. Saturated Steam Table with steam properties as specific volume, density, specific enthalpy and specific entropy. Air flow required to remove vapor production from a room. Steam table with sensible, latent and total heat, and specific volume at different gauge pressures and temperatures. Calculate outdoor swimming pool heaters. Online calculator, figures and tables showing boiling points of water at pressures ranging from 14.7 to 3200 psia (1 to 220 bara). Temperature given as C, F, K and R. Thermal properties of water, including density, specific heat capacity, thermal conductivity, and thermal expansion at different temperatures. Online calculator, figures and tables with water saturation (vapor) pressure at temperatures ranging 0 to 370 C (32 to 700F) - in Imperial and SI Units. Alison Nugent and Shintaro Russell By the end of this chapter, you should be able to:Compute saturation vapor pressure using the Clausius-Clapeyron equation;Convert between humidity variables. Differentiate between relative humidity, specific humidity, absolute humidity, wet-bulb temperature, mixing ratio, and dew point;Describe the conditions for saturation to occur;Apply the moist adiabatic lapse rate;Use the principles of phase change and latent heating to describe why the moist adiabatic lapse rate is less than the dry adiabatic lapse rate. Water can exist as a solid, liquid, or gas at typical conditions found on Earth. As we learned, the process of liquid water becoming water vapor is called evaporation and this process absorbs or requires energy. The opposite process is called condensation, where water vapor becomes liquid water, releasing energy. Condensation is especially important in atmospheric science because this is the process that allows clouds to form.Phase changes of water from gas (water vapor) to liquid (water) to solid (ice) with the names for the processes also labeled. (CC BY 2.0).Clouds are composed of millions and billions of tiny liquid water droplets. How do they form? Why are they there?Water droplets condensed on a glass surface (CC BY 2.0).Before we can understand clouds in the atmosphere, we need to explore concepts like how humidity is defined and what saturation means.In general, humidity is the amount of water vapor in the air. Youve likely heard of relative humidity and dew point temperature, but what do these quantities mean physically? Imagine a closed jar filled halfway with water. At the initial time, more water molecules evaporate from the water surface than the number that return. However, after some time, the number of molecules evaporating from the surface will be equal to the number of molecules condensing back into the water surface. When condensation and evaporation are equal, this is called saturation.Saturation occurs when air contains the maximum amount of water vapor possible for its given temperature. That is why condensation equals evaporation. If evaporation occurs, the air cannot contain more water vapor, so some must condense. Now lets get quantitative.Vapor pressure at saturationEvery gas in the atmosphere exerts pressure, for example, vapor pressure makes up a fraction of the total atmospheric pressure. In the following equation, all of the gases in Earths atmosphere contribute to the total atmospheric pressure Patmosphere. Specifically for water vapor, the more water vapor that is added to the atmosphere, the higher the vapor pressure PH2O. The units for vapor pressure are the same as pressure and can be in Pascals, hectoPascals, or kiloPascals. Because we are staying consistent with Roland Stulls Practical Meteorology textbook, we will use kiloPascals (kPa) throughout this chapter.The amount of water vapor that the atmosphere can contain depends on temperature. Lower temperature air cannot contain as much water vapor as higher temperature air. If we think of this quantitatively in terms of pressure,saturation vapor pressure refers to the pressure exerted by the movement of water vapor molecules exerted over a surface of liquid water. When the partial pressure exerted by water vapor is equal to the saturation vapor pressure, the air is saturated.The Clausius-Clapeyron equation gives the approximate relationship between saturation vapor pressure (es) and temperature in the atmosphere where the water-vapor gas constant v is 461 JK1kg1, T0is 273.15 K, e0is 0.6113 kPa, and Lv is the latent heat of vaporization, 2.5106 Jkg1. Thisresults in Lv/v being equal to 5423 K. In this equation, units for temperature must be in Kelvin. Note that in the equation above, exp[x] implies the exponential function ex, but it is written on one line for visual purposes.A graph of the saturation vapor pressure as a function of temperature showing the exponential relationship between the two from the Clausius-Clapeyron equation (Modified fromCC BY-SA 4.0).The image shows the relationship between temperature and saturation vapor pressure based on the Clausius-Clapeyron equation. Lower temperatures are saturated with respect to water vapor at lower vapor pressures, while higher temperatures need higher vapor pressures to be saturated. Temperature is the primary factor determining water vapor saturation.In the graph of saturation vapor pressure vs. temperature notice the saturation vapor pressure value at the boiling temperature, 100C. The saturation vapor pressure value es(100C)=101.325 kPa, is the same value as the atmospheric surface pressure. Water boils at the Earths surface when the saturation vapor pressure is equal to the atmospheric pressure, which is why water boils at 100C. Will water boil at the same temperature at the top of Mount Everest? Vapor pressure is one way of defining humidity, but there are many others. Here is a non-comprehensive list of humidity variables and their typical units.e = vapor pressure (kPa)r = mixing ratio (gkg1)q= specific humidity (gkg1)v = absolute humidity (gm-3)RH = relative humidity (%)zLCL = lifting condensation level (km)Td = dew point (temperature) (C)Tw = wet-bulb temperature (C)Vapor PressureWeve already discussed saturation vapor pressure, es, but you can also compute vapor pressure, e. However, because Tdis often unknown, the easiest way is usually through relative humidity. Again, e0is 0.6113 kPa,Lv is 2.5106 Jkg1, v is 461 JK1kg1, T0is 273.15 K, and Td is dew point temperature, which will be defined later.Mixing RatioMixing ratio, r, is the ratio of the mass of water vapor to the mass of dry air. It is typically expressed as grams of water vapor per kilogram of air (gkg1). Pressure (P) should be in the same units as vapor pressure (e).The constant is 0.622, is the ratio between the gas constant for dry air and the gas constant for water vapor. Saturation mixing ratio, rs, is computed the same way as the mixing ratio but with saturation vapor pressure, es, instead of e. When calculating mixing ratio, the pressure units on the top of the fraction will cancel with the pressure units on the bottom of the fraction. While it appears unit-less, its technically not based on its definition of mass of water vapor as compared to mass of dry air. See the Pro Tip below for more information.Pro Tip: Many units of moisture are given in gkg-1 or kgkg-1so technically the units could cancel and it could be unitless! Dont let this fool you. It is important to remember that the mass in the numerator and denominator are different. In the case of mixing ratio, the value is given in mass of water vapor proportional to the mass of dry air.Specific HumiditySpecific humidity, q, is the ratio of the mass of water vapor to the total mass of air (dry air and water vapor combined). It is expressed as grams of water vapor per kilogram of air (gkg1). Again, saturation specific humidity, qs, is computed with es instead of e. Absolute HumidityAbsolute humidity,v, is the ratio of the mass of water vapor to the volume of air. It is expressed as grams of water vapor in a cubic meter of air (gm-3). It is effectively water vapor density. Again, saturation absolute humidity,vs, uses es instead of e. Relative HumidityRelative humidity, RH, is the ratio of the amount of water vapor present in the air to the maximum amount of water vapor needed for saturation at a certain pressure and temperature. It is typically multiplied by 100 and expressed as a percent. Relative humidity shows how close the air is to being saturated, not how much water vapor the air contains. For this reason, RH is not a good indicator of the quantitative amount of water vapor in the air. It is only a relative measure that is highly dependent on the air temperature. Relative humidity greater than 100% is called supersaturation. or Imagine two parcels of air with the same volume, pressure, and relative humidity. Parcel 1 has an air temperature of 20C while Parcel 2 has an air temperature of 30C. Which parcel contains more water vapor?Dew Point TemperatureThe dew point temperature, Td, is the temperature to which the air must be cooled to reach saturation, without changing the moisture or air pressure. It measures the actual moisture content of a parcel of air. Saturation occurs when the dew point temperature equals the air temperature. When the dew point temperature is lower than the freezing point of water, it is also called the frost point.Wet-Bulb TemperatureWet-bulb temperature, Tw, is the lowest temperature that can be achieved if water evaporates within the air. When the relative humidity is 100%, the wet-bulb temperature is equal to the air temperature because there is no evaporation.The wet-bulb temperature is difficult to calculate but easy to measure. To measure the wet-bulb temperature, all you need is a thermometer with a wet cloth wrapped around the bulb. Typically this thermometer is attached to an apparatus called a sling psychrometer to make it easy to spin around in the air to create lots of airflow over the wet cloth on the thermometer. The evaporation from the wet cloth cools the temperature measured, hence the wet-bulb temperature is always lower than the air temperature (or dry-bulb temperature) when relative humidity is less than 100%.You can also estimate the wet bulb temperature using lines on a graph. Normands Rule is used to calculate the wet-bulb temperature from the air temperature and the dew point temperature. The wet-bulb temperature is always between the dew point and the dry-bulb temperature (Td Tw T). This can be implemented on thermodynamic diagrams, such as the Skew-T log P, which is discussed in more detail in the next chapter.Take note of this description for later. To find the wet-bulb temperature on a Skew-T log Pdiagram, follow the dry adiabatic lapse rate line upward from the air temperature. Next, use the dew point temperature and follow an isohume (line of constant relative humidity) upward. The point where these two lines meet is called the lifting condensation level (LCL). From the meeting point, follow the moist (saturated) adiabatic lapse rate back down to obtain the wet-bulb temperature value. This is probably confusing at this point because we have not discussed the LCL or the moist adiabatic lapse rate, but dont worry, well repeat this logic again in the next chapter to make sure this is clear. You may be wondering at this point why we care so much about moisture and why we need so many definitions of (almost) the same thing. The reason is that moisture is an extremely important atmospheric property. Water can exist in three phases (vapor, liquid, ice) within the atmosphere at typical pressures and temperatures. It has an especially large impact on the human experiencethink about a humid day, foggy conditions, rain, snow, or even hail! Less obvious is its impact on atmospheric stability, which drives the aforementioned conditions.For now, lets think about the process of water vapor condensing to form liquid water. There is one final definition of humidity that will be helpful.Lifting Condensation LevelThe lifting condensation level, zLCL, is the altitude where clouds form. At the LCL, temperature equals the dew point temperature, resulting in saturation and therefore condensation. The height (z) of the LCL is where a is 0.125 kmC-1. We can also define the temperature at the LCL as follows. Moist Adiabatic Lapse RateIn the last chapter, we discussed how temperature changes as a dry parcel of air is lifted in the atmosphere. You will recall that as an air parcel is lifted, the temperature drops by 9.8 K every kmdue to the work the air parcel must do to the environment as it expands. Lets add moisture to the discussion and see how this changes things.If the air parcel reaches saturation (100% relative humidity) and water vapor condenses to liquid water within the parcel, latent heat will be released. In the case of a rising air parcel that is cooling from adiabatic expansion, this added heat from condensation counterbalances some of the cooling. Hence, the air parcel will no longer cool at the dry adiabatic lapse rate but at the smaller moist adiabatic lapse rate (m). Unlike the dry adiabatic lapse, the moist adiabatic lapse rate is not constant and varies based on the temperature and moisture of the air parcel.We will approximate the moist adiabatic lapse rate with the following value. The difference between the dry adiabatic lapse rate (m) and the moist adiabatic lapse rate (m)is significant and has profound influence on atmospheric stability, the topic of the following chapter.Explain the conditions needed for saturation to occur.What is the saturation vapor pressure of air at 26C?Explain the difference between specific humidity and relative humidity.If the temperature is 10C and the pressure is 700 hPa, calculate the saturation specific humidity and the saturation mixing ratio.Explain why the moist adiabatic lapse rate is less than the dry adiabatic lapse rate.Selected Practice Question Answers: Published By: Calculator Academy Last Updated: August 14, 2024 Enter the velocity of air above the water surface, the water surface area, the maximum humidity ratio of saturated air, and the current humidity ratio of air to determine the evaporation rate of water from a surface. The following formula is used to calculate the evaporation rate of water. gh = (25+19*v)*(A)*(Xs-X) Where gh is the evaporation rate (kg/h) v is the velocity of air above the surface (m/s) A is the water surface area (m^2) Xs is the maximum humidity ratio of saturated air (at the same temperature as the water surface) X is the current humidity ratio air To calculate the evaporation rate, multiply 19 by the velocity of the air, add 25 to the result, multiply by the surface area, then multiply by the difference in current humidity ratio and maximum humidity ratio. An evaporation rate is defined as the speed at which water is evaporated into air typically measure in weight per unit of time. How to calculate an evaporation rate? First, determine the velocity of air. Measure the speed of the air above the surface of the water. Next, determine the surface area. Calculate the total water surface area exposes to air. Next, determine the maximum humidity ratio. Calculate the maximum humidity ratio of saturated air at the same temperature as the surface of the water. Next, determine the current humidity ratio. Calculate the current humidity ratio of the air. Finally, calculate the rate of evaporation. Calculate the water evaporation rate using the equation above. What is an evaporation rate? An evaporation rate is a speed at which water is evaporated from the surface of a body of water.

Mixing ratio water vapor. Evaporation rate of water. Mixing ratio water.

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