PROBLEMS

1. 1 Fog formation

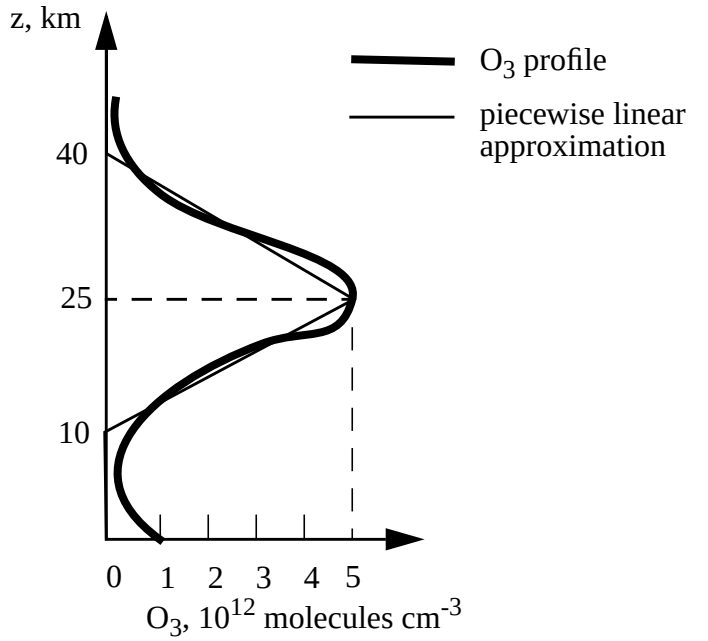
A weather station reports T = 293 K, RH = 50% at sunset. Assuming that P_{H2O} remains constant, by how much must the temperature drop over the course of the night in order for fog to form?

1. 2 Phase partitioning of water in cloud

What is the mass concentration of water vapor (g H_2O per m^3 of air) in a liquid-water cloud at a temperature of 273 K? Considering that the liquid water mass concentration in a cloud ranges typically from 0.1 to 1 g liquid water per m^3 of air, is most of the water in a cloud present as vapor or as liquid?

1. 3 The ozone layer

Consider the following typical vertical profile of ozone (O_3) number densities measured over the United States. Ozone is produced in the stratosphere (10-50 km altitude) by photolysis of O_2 and subsequent combination of O atoms with O_2 (chapter 10). The stratospheric O_3 layer protects life on Earth by absorbing solar UV radiation and preventing this radiation from reaching the Earth's surface. Fortunately, the O_3 layer is not in contact with the Earth's surface; inhalation of O_3 is toxic to humans and plants, and the U.S. Environmental Protection Agency (EPA) has presently an air quality standard of 80 ppbv O_3 not to be exceeded in surface air.



1. Calculate the mixing ratio of O_3 at the peak of the O_3 layer (z = 25 km; P = 35 hPa; T = 220 K). Would this mixing ratio be in violation of the EPA air quality standard if it were found in surface air? (moral of the story: we like to have a lot of O_3 in the stratosphere, but not near the surface)

2. Calculate the mixing ratio of O_3 in surface air (z = 0 km; P = 1000 hPa; T = 300 K). Is it in compliance with the EPA air quality standard? Notice that the relative decrease in mixing ratio between 25 km and the surface is considerably larger than the relative decrease in number density. Why is this?

3. The total number of O_3 molecules per unit area of Earth surface is called the *O_3 column* and determines the efficiency with which the O_3 layer prevents solar UV radiation from reaching the Earth's surface. Estimate the O_3 column in the above profile by approximating the profile with the piecewise linear function shown as the thin solid line.

4. To illustrate how thin this stratospheric O_3 layer actually is, imagine that all of the O_3 in the atmospheric column were brought to sea level as a layer of pure O_3 gas under standard conditions of temperature and pressure (1.013×10^5 Pa, 273 K). Calculate the thickness of this layer.