Exercise No. 1 / METCLOUD WS19/20

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October 7, 2019

Instructions

- **Deadline for submission**: Thursday 17 October, 2019 at noon (12:00 p.m.).
- **How to submit**: Send the solutions in .pdf format to `l.kliesch@uni-koeln.de` OR leave a hard copy of the solutions in my mail box (`Kliesch`) in room 3.124 OR bring a hard copy of the solutions to my office in room 3.147, Pohligstr. 3.
- Please hand in individually. Don't forget to put your name on your solution.
- Remember, that you have to collect at least 50 % the points on all exercise sheets to be admitted to examination.

1) (2P) Which role do clouds play in the climate system?

2) (2P) Why are clouds so difficult to predict in numerical weather prediction and climate models?

3) (2P) How do clouds modulate the global energy budget of the atmosphere?

4) (2P) Imagine a pure water cloud which consists of cloud droplets of uniform size with radius $r_d = 5\,\mu\text{m}$. Assume a uniform spacing of cloud droplets, with a number concentration of $N_c = 170\,\text{cm}^{-3}$.

1. (0.5P) Calculate the liquid water content (LWC) M_l and give its value in $\text{g}\,\text{m}^{-3}$.
2. (0.5P) How much is the volume fraction of water?
3. (0.5P) How much is the average distance from one droplets to its nearest neighbor? Assume a regular cubical grid pattern of the droplets.
4. (0.5P) How would the distance between cloud droplets change if their number concentration is tripled?

5) (2P) Calculate and compare:

1. (1P) How much water is in a cumulus congestus cloud with $LWC = 0.5\,\text{gm}^{-3}$, horizontal/vertical dimension=5000 m/4000 m? Compare to a bathtub ($V = 2\,\text{m}^3$).
2. (1P) What is its energy of condensation? (specific heat of condensation of water $\approx 2.5 \times 10^6\,\text{J}\,\text{kg}^{-1}$). Compare to the Nagasaki Bomb (22 kT TNT; 1 kT TNT = 4.2×10^{12} J).

6) (2P) Depending on application the ideal gas law is written in several different formulations. Write as many different formulations as possible and explain the different variables involved.