UNIVERSITY OF OSLO

The Faculty of Mathematics and Natural Sciences

Mid-term exam in: GEF 4310 / GEF 9310 Cloud Physics
Date of examination: 24 March 2010
Time of examination: 15:00-18:00
The problem set consists of 6 pages
Attachments: None
Permitted aids: None

Check that the problem set is complete before you start solving the problems.

The first 6 problems are multiple-choice problems. Mark your answer with a tick mark. There is only 1 correct answer per problem. In problems 7 and 8 you are asked for detailed answers. The problems 1-6 count 10% each, while problems 7 and 8 count 20% each.

Problem 1

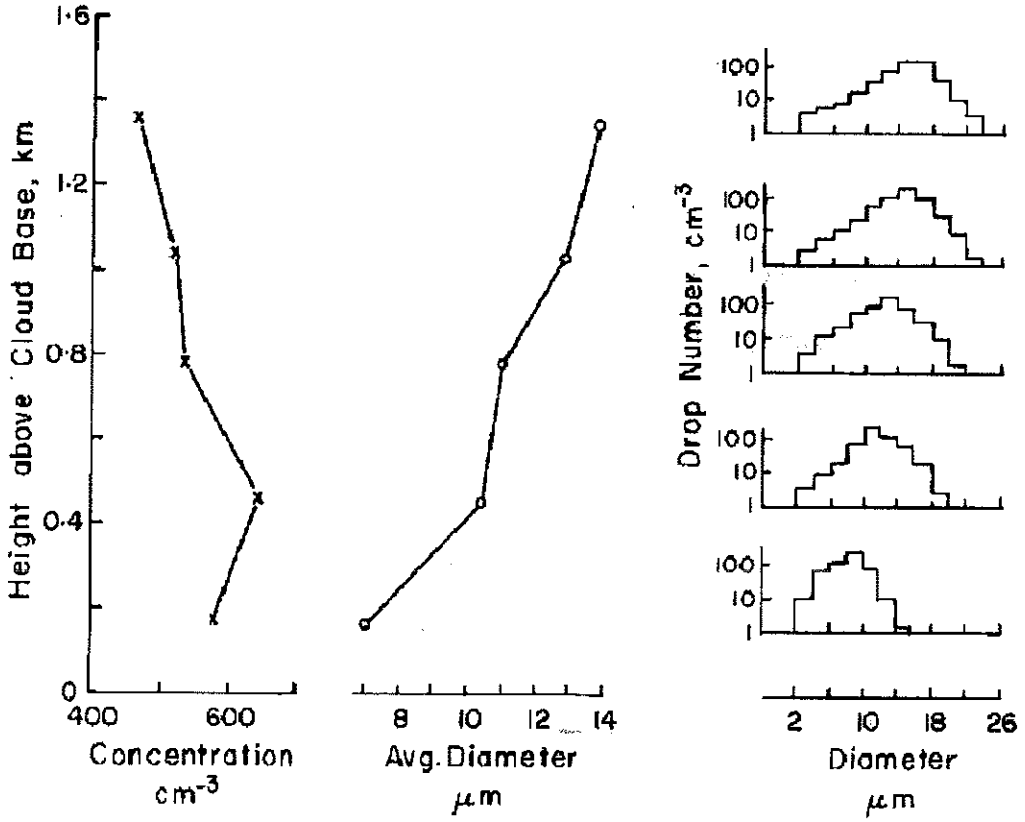
The equation $\frac{d}{dt}(T_p - T) = -E(T_p - T) - E\frac{L\mu}{c_p} - (\Gamma - \gamma_c)\frac{dz}{dt}$ describes mixing due to entrainment of an air parcel at cloud top, where $E = \frac{1}{m}\frac{dm}{dt}$ is the entrainment rate. Which of the following statements is correct?

nei a) Mixing at cloud top is inefficient compared to lateral mixing.
nei b) Both the first and the second term on the right describe evaporative cooling.
nei c) The entrained air parcel is warmer than the cloudy air.
× d) Only the second term on the right causes downward acceleration of the entrained parcel.
nei e) Downward acceleration of the entrained parcel can be described by a mechanism called CISK = Conditional Instability of the Second Kind.

Problem 2 Se s. 69

The figure below shows observed conditions in a convective cloud. Which of the following is correct?

nei a) The cloud droplet concentration decreases with height, mainly due to evaporation. bruinregen+koalisens
X b) The collision-coalescence mechanism is clearly operating.
nei c) The cloud droplet size increases with height, mainly due to condensation. zoals a)
nei d) The cloud droplet size distribution widens with height due to the presence of ice crystals. zoals a)
nei e) The cloud droplet number concentrations seen in the figure are characteristic of maritime convective clouds. for hoogte (fig 5.9)



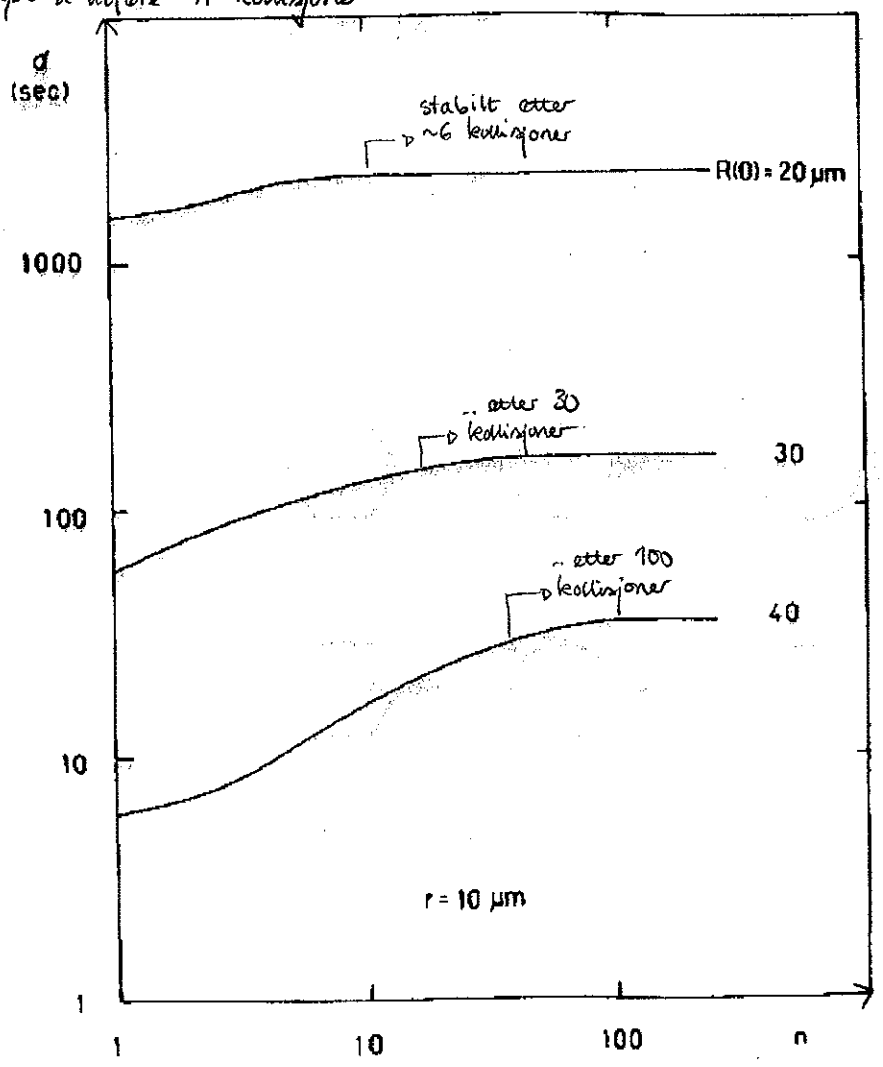
Problem 3

The figure below is from the quasi-stochastic collision-coalescence model of Telford. Which of the following statements is correct?

nei a) The figure shows that the droplet size distribution is widest for small droplet radii.
nei b) The figure shows that stochastic effects are only important for large collector drops (40 µm).
X c) The figure indicates that stochastic effects are unimportant after the first 20 captures, or so.
nei d) The figure shows that large collector drops (40 µm) are less frequent than small ones (20 µm).
nei e) The figure shows that with increasing cloud droplet number (n), the time (σ) it takes to develop precipitation increases.

σ: standardavviket til tiden det tar en dråpe å "utføre" n kollisjoner

Hvis rett svar: forvirrende tall



obs! n er ikke dråpeantall, men antall kollisjoner

Problem 4

The figure below shows different mechanisms for heterogeneous ice crystal nucleation. Which of the following statements is correct?

X a) Heterogeneous deposition is the only one that can operate when $e_i < e < e_s$.

nei b) The figure shows all possible mechanisms for ice crystal nucleation in the atmosphere.

nei c) Bacteria are believed to be the dominating ice nuclei in the atmosphere.

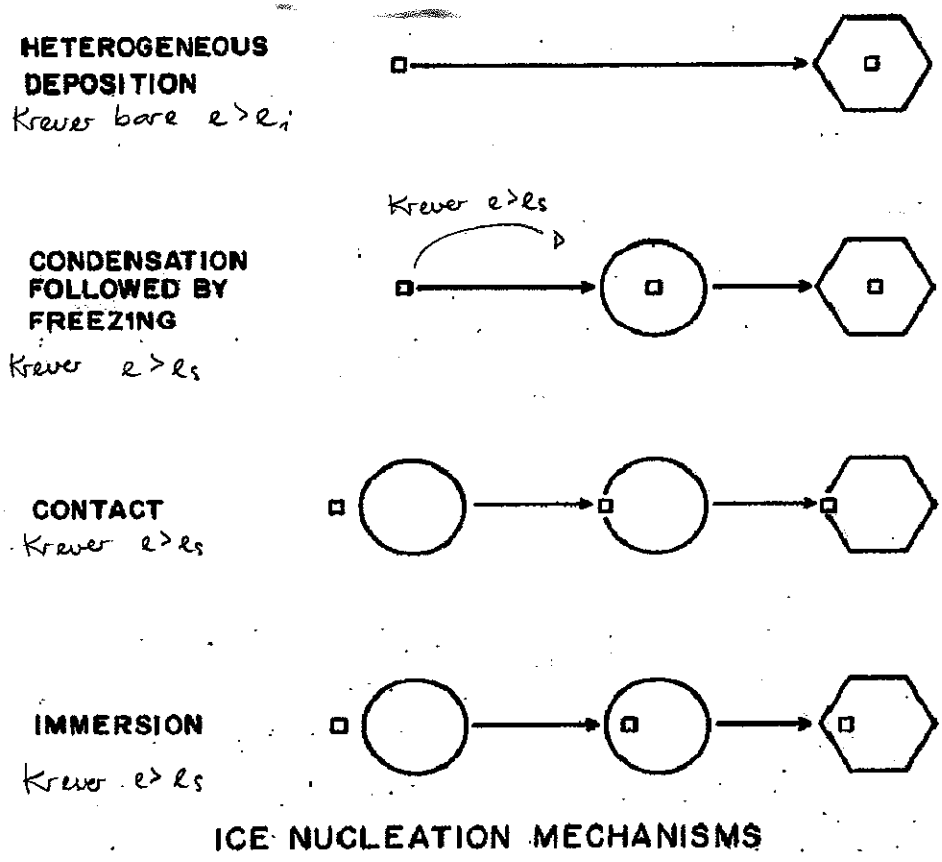
nei d) Ice nuclei have the largest concentrations at temperatures near -20°C.

nei e) The ice crystals shape (dendrite, column, needle, plate) is determined by the nucleation mechanisms shown in the figure.

Nei, for homogen nukleasjon er også nukleig, T < -40°C

Nei, bestemmes av graden av overmetning (og temp.)

Vi sier "typiske 1 per liter ved -20°C" men er veldig variabelt, Generelt flere partikler ved lavere temperaturer og større overmetning Se Fig. 9.2 s. 157 - antall IN øker videre etter -20°C..



ICE NUCLEATION MECHANISMS

Oppgave 5

In the weather radar equation: $10 \log P_r = 10 \log Z + 20 \log r + C$, the term Z:

___ a) Is determined by instrument characteristics.
___ b) Is the refractive index of either water or ice.
___ c) Depends on the distance to the target.
X d) Is a measure of the size of the precipitating particles.
___ e) Expresses the power returned from the target.

→ $Z = \sum_{\text{sum over volume}} D^6 = \int_0^\infty N(D) D^6 dD$

Problem 6

Kinetic effects:

___ a) Are important only for evaporation.
___ b) Are important only for growth by collisions and coalescence.
___ c) Can be ignored.
___ d) Are expressed by the collisional kinetic energy, CKE.
X e) Are important for diffusional growth by ice crystals.

Problem 7

The governing equation in the Bowen model is the following: $\frac{dR}{dz} = -\frac{\overline{E}M}{4\rho_L}$

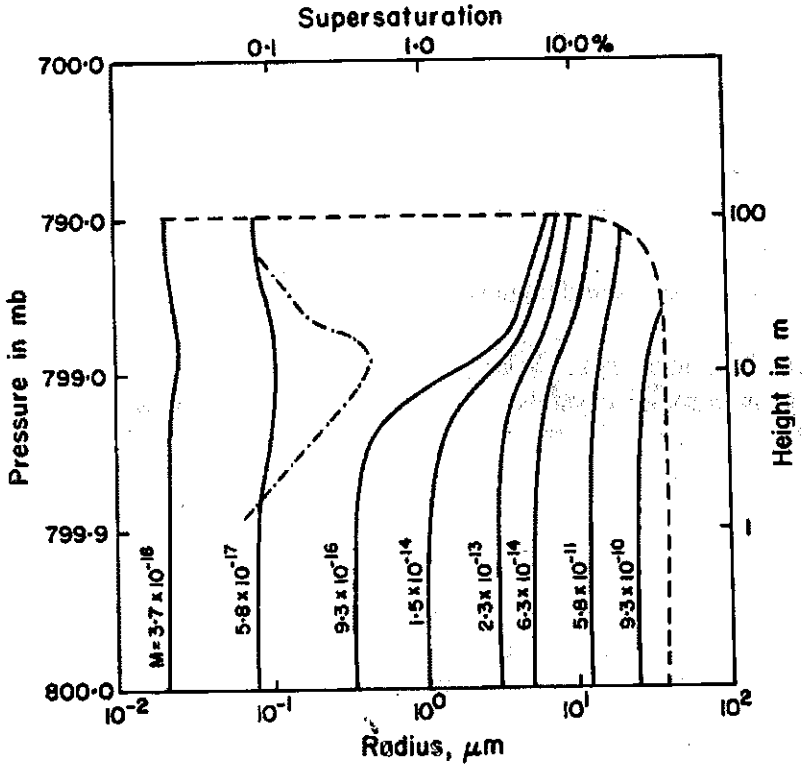
- R: oppsamlerdråpes radius
- $\overline{E}$: midlere kollisjonseffektivitet
- M: skyvannsinnhold, LWC
- ρ_L: tetthet av vann

✓ a) Explain all the terms in the equation.
b) Derive the equation.
c) What process does the equation describe? Vekst av en dråpe ved kollisjon-koalesens.
d) How well does this model describe what happens in nature?

Problem 8 se s.108

The figure below is based on calculations that were carried out starting with an assumed CCN distribution and an assumed updraft velocity (0.15 m s^{-1}).

a) Explain what the figure shows.
b) How would the figure change if the updraft velocity were doubled (to 0.30 m s^{-1})?



a) - bare dråper over en viss masse blir aktivert
- de største dråpene