Lecture 1, GEF4310 "Cloud Physics"

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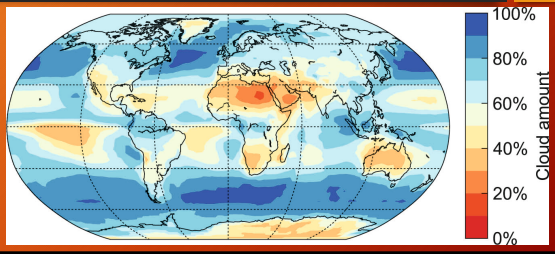
Spring 2018

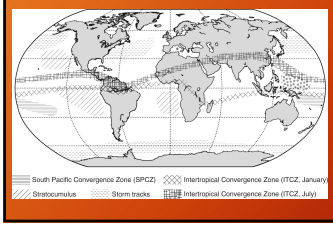
Schedule, Spring 2018

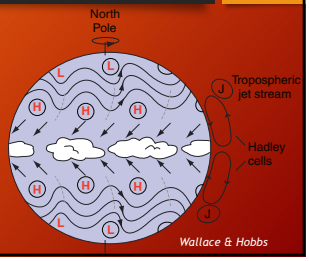
Week #	Monday (exercises)	Wednesday (lectures)
3	(15/1) No class	(17/1) Introduction and descriptive overview of clouds (Ch. 1)
4	(22/1) No class	(24/1) Thermodynamics (Ch. 2.1 - 2.3)
5	(29/1) Thermodynamics exercises	(31/1) No class
6	(5/2) No class	(7/2) Thermodynamics (Ch. 2.4 - 2.5)
7	(12/2) Thermodynamics exercises	(14/2) Stability & convection (Ch. 3.1.5, 3.2, 3.3 and 4.2)
8	(19/2) Stability/convection exercises	(21/2) Atmospheric aerosols (Ch. 5)
9	(26/2) Aerosols exercises	(28/2) No class
10	(5/3) No class	(7/3) Droplet formation (Ch. 6)
11	(12/3) Droplet formation exercises	(14/3) Warm cloud microphysics (Ch. 7)
12	(19/3) Warm cloud microphysics exercises	(21/3) No class
13	Friday 23/3 Mid-term exam (NOTE: extra Q&A class will be scheduled this week)	
13	(26/3) No class (Påske)	(28/3) No class (Påske)
14	(2/4) No class (Påske)	(4/4) Ice nucleation (Ch. 8.1 and 8.2)
15	(9/4) No class (EGU)	(11/4) No class (EGU)
16	(16/4) Ice nucleation exercises	(18/4) Cold cloud microphysics (Ch. 8.3 - 8.5)
17	(23/4) Cold cloud microphysics exercises	(25/4) Precipitation/radar (Ch. 9.1 - 9.4)
18	(30/4) No class	(2/5) Aerosol/cloud radiative effects (Ch. 11)
19	(7/5) Precip./radar + radiative eff. exercises	(9/5) Aerosol-cloud interactions (Ch. 12.1 and 12.2)
20	(14/5) Aerosol/cloud interaction exercises	(16/5) Cloud/climate feedbacks (Ch. 12.3)
21	(21/5) No class (Pinse)	(23/5) Climate engineering (Ch. 12.4)
22	Exam week of May 28 - Jun 2	

Satellite observations of global cloud cover (global mean of ~70%)



Reminder, global atmospheric circulation





Wallace & Hobbs

Overview of cloud types

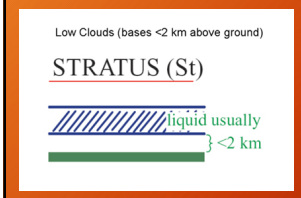
- **Cumulus** = heap-like or cauliflower-like, usually associated with strong vertical motion (instability), vertical extent often larger than horizontal extent. Cloud lifetimes relatively short.
- **Stratus** = layered/flat clouds, usually connected to weaker & large-scale vertical motion, large horizontal extent. Longer cloud lifetimes.
- **Cirrus** = fibrous/wispy-looking clouds, generally high, always consist of ice.

Fog

Coverage over land and ocean ~1%

From R. Houze's Cloud Atlas

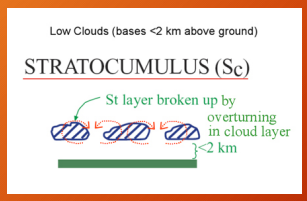
Stratus



Covers 2-5% of land, 2-13% of ocean

From R. Houze's Cloud Atlas

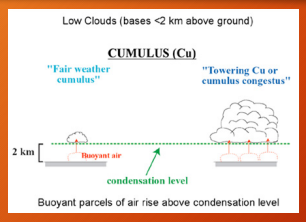
Stratocumulus



Covers 8-13% of land, 8-22% of ocean

From R. Houze's Cloud Atlas

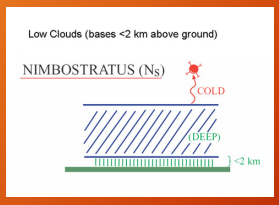
Cumulus



Covers 5-8% of land, 13-15% of ocean

From R. Houze's Cloud Atlas

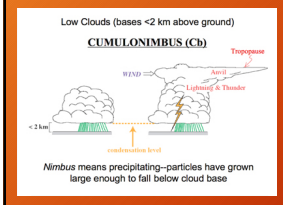
Nimbostratus



Covers 2-4% of land, 3-5% of ocean

From R. Houze's Cloud Atlas

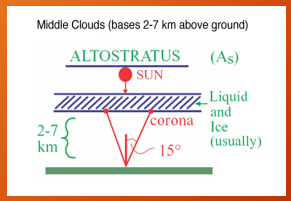
Cumulonimbus



Covers 3-5% of land, 2-6% of ocean

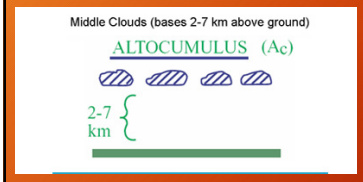
From R. Houze's Cloud Atlas

Altostratus



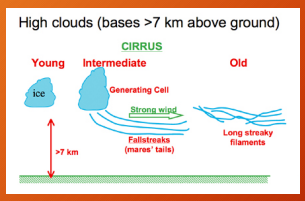
From R. Houze's Cloud Atlas

Altocumulus



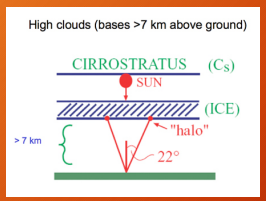
From R. Houze's Cloud Atlas

Cirrus



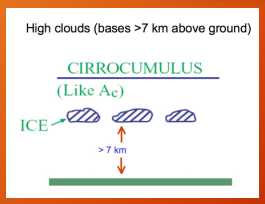
From R. Houze's Cloud Atlas

Cirrostratus



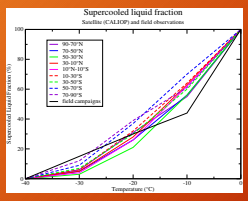
From R. Houze's Cloud Atlas

Cirrocumulus

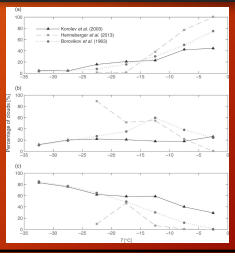


From R. Houze's Cloud Atlas

Cloud thermodynamic phase



Storelvmo (Annual Reviews, 2017)



Liquid percentage

Mixed-phase percentage

Ice percentage

Cloud droplets vs. ice crystals

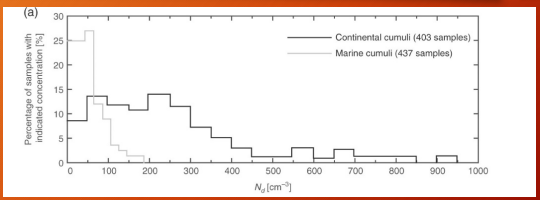
Cloud droplets

- Typical size (radius) 2 -25 μm
- Typical number concentrations 10 – 1000 cm^{-3}
- Typical liquid water contents: 0.1 – 5 gm^{-3}
- Usually spherical

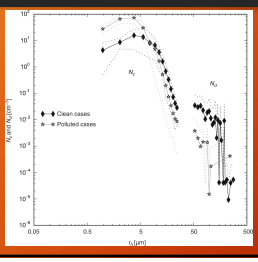
Ice crystals

- Typical size (length) 1 – 1500 μm
- Typical number concentrations 10^{-4} – 10 cm-3
- Typical ice water contents: 10^{-4} - 0.5 gm^{-3}
- Usually non-spherical (often hexagonal)

Continental vs. marine clouds



Clean vs. polluted clouds



- Figure shows cloud droplet (N_c) and drizzle drop (N_d) size distributions for clean clouds (diamonds) and polluted clouds (asterisks).
- The size distributions tend to resemble gamma distributions.
- Polluted clouds have more/smaller cloud droplets, but fewer drizzle drops.