Cloud microphysical properties

Instructions for the asignment

CloudyColumn ACE-2 (Second Aerosol Characterization Experiment); Stratocumulus clouds

Literature

Raes, F., Bates, T., McGovern, F., and Van Liedekerke, M., 2000.: The 2nd Aerosol Characterization Experiment (ACE-2): general overview and main results. *TELLUS SERIES B-CHEMICAL AND PHYSICAL METEOROLOGY, Volume*: 52, Issue:2, Pages: 111-125, DOI: 10.1034/j.1600-0889.2000.00124.x

Brenguier, J.L., Chuang, P.Y., Fouquart, Y., Johnson, D.W., Parol, F., Pawlowska, H., Pelon, J., Schuller, L., Schroder, F., and Snider, J., 2000: An overview of the ACE-2 CLOUDYCOLUMN closure experiment. *TELLUS SERIES B-CHEMICAL AND PHYSICAL METEOROLOGY,* Volume: 52, Issue: 2, Pages: 815-827, DOI: 10.1034/j.1600-0889.2000.00047.x

Brenguier, J.L., H. Pawlowska, and L. Schueller, 2003: Cloud microphysical and radiative properties for parameterization and satellite monitoring of the indirect effect of aerosol on climate. *J. Geophys. Res.-Atmos.*, 108 (D15), 8632, doi:10.1029/2002JD002682

Pawlowska, H., and J. L. Brenguier, 2000: Microphysical properties of stratocumulus clouds during ACE2. *Tellus*, 52B, 867-886, doi: 10.1034/j.1600-0889.2000.00076.x

Data

Data description: ReadMe_ACE2.txt
Data files:

- 113747.2H0001 data form the flight nr. fr9721 from 26 June 1997 r.
- 121129.4H0001 data from the flight nr. fr9730 from 9 June 1997 r.

comment: 'fr' indicates that the flight was performer by the French aircraft, '97' indicates the year (1997), '21' or '30' is the flight number.

The file name has a form hhmmss.dH0001, where hh, mm, ss, d denote the start time of measurements in hour (hh), minutes (mm), seconds (ss) and tenths of second (d). '0001' at the end of the file name means that data are registered with a frequency of 1Hz.

Measurements were performed by the Fast Forward Scattering Spectrometer Probe (FFSSP).

Tasks TODO

Do separately for each flight. Discuss results and compare between flights.

Plot the trajectory of the flight in longitude-latitude coordinates (column 26 and 25 in data files; description of parameters in ReadMe.txt).

1. Plot the altitude of the aircraft as a function of time
2. At the beginning of each flight the aircraft is performing a vertical sounding of the atmosphere. Plot the vertical profiles of temperature and water vapor mixing ratio.

Calculate the value of potential temperature and plot its vertical profile from the sounding. Estimate the level of inversion of temperature.

3. Using all data from a given flight make a scatter plot the Liquid Water Content (LWC) in function of altitude.
    3.1. Estimate the position of the cloud base, and the values of pressure and temperature at the cloud base.
    3.2. Calculate the condensation rate coefficient, $c_w = \rho \frac{c_p}{L_v}(\Gamma_d - \Gamma_s)$, where ρ is air density, c_p is specific heat at constant pressure, L_v is latent heat of vaporization, Γ_d and Γ_s is dry adiabatic and saturated adiabatic lapse rates respectively. The condensation rate coefficient can be estimated as a function of temperature and pressure at the cloud base only (see Chapter 6.5 in *Thermodynamics of Atmospheres&Oceans* by Judith A. Curry and Peter J. Webster). The liquid water content in shallow clouds increases linearly with height above the cloud base (h): LWC=c_w·h. Plot a line LWC=c_w·h in the scatter plot of LWC – h figure.
4. Now, take only data from the 'vertical' profiles, i.e. when the aircraft traverse the loud layer form the base to the top, or from the top to the base.
    4.1. For all 'vertical' profiles make scatter plots of LWC (column 20), droplet number concentration (column 18) and mean volume diameter (column 23) in function of altitude. In the LWC-h figure plot the line LWC=c_w·h as in 3.2.
    4.2. For all 'vertical' profiles plot parameters describing sizes of cloud particles: mean diameter, mean volume diameter, effective diameter. Discuss differences between those parameters.
    4.3. The cloud droplet spectrum can be represented by percentiles of the droplet size distribution (19 values corresponding to 5^{th} up to 95^{th} percentile). The width of the droplet spectrum can be approximated by the difference between 95^{th} and 5^{th} percentile. For few chosen 'vertical' profiles show how the droplet spectrum width varies with altitude.