Assignment 9 FYS4630/FYS9630

Wednesday November 12, 2014

1. The solution of the radiative transfer equation for layer *p* for a multi-layered atmosphere is

$$I_p^{\pm}(\tau,\mu_i) = \sum_{j=1}^{N} C_{-jp}g_{-jp}(\pm\mu_i)e^{k_{jp}\tau} + \sum_{j=1}^{N} C_{jp}g_{jp}(\pm\mu_i)e^{-k_{jp}\tau} + Z_{0p}(\pm\mu_i)e^{-\tau/\mu_0}$$

$$i = 1, \ldots, N$$

   We here consider solar radiation only and therefore neglect thermal radiation.
   Assume a two layer atmosphere with a non-reflecting lower boundary and with N = 1 in the equation above (two-stream). Show that by introducing the scaling transformation in the text book (Eq 8.57, page 303) the 'ill-conditioning' in the determination of the $C_{\pm jp}$ is completely removed.

2. A satellite is used to measure the spectral intensity of backscattered solar radiation (τ = 0, μ = 1).

   a) The measured intensity can be used to infer the total column ozone amount. Explain why it is difficult to measure ozone variations in the troposphere. Download the code 'uvspec-assignment9.zip'. Simulate the satellite measurement with this code. Assume first a wavelength of 305 nm solar zenith angle 30°, surface albedo 0.05, and clear sky. In your discussion you can compute the intensity for the following situations: i) using the ozone profile as is, ii) reduce the ozone amount in the bottom layer (0 – 1 km) by 1 DU, iii) reduce the ozone in layer 15-16 km by 1 DU, ozone in the bottom layer as in i). Use the results in your discussion. Will a longer wavelength, e.g. 320 nm, be a better choice for the determination of the total ozone column?
   Edit the file subarcticwinterN.atm to make your ozone changes. (Do not make changes in the columns 'Mie-ext' and 'ssalb mie'. These are ingnored in this version of the code). The output of the simulations are found in the file 'spect.out'.

   b) The satellite is also used to estimate the surface albedo. Explain why it is difficult to derive the surface albedo for cloudy conditions. Compute the intensity for the following situations: i) clear sky surface albedos 0.05 and 0.8, ii) a cloud between 2 km and 6 km of optical thickness 100, cloud single scattering albedo 1.0, asymmetry factor 0.85 for surface albedos 0.05 and 0.8. (Do not make changes in the columns 'Mie-ext' and 'ssalb mie'. These are ingnored in this version of the code). Assume solar zenith angle 30° and a wavelength of 340 nm. Use the results in your discussion. The output of the simulations are found in the file 'spect.out'.