```
% refresh memory
clear all

% change display for all plots
set(0, 'DefaultAxesFontSize', 12, 'DefaultLineLineWidth', 2)

% define the name of the input file

% you can download some simulated data that we used for comparison
% http://lalinet.org/uploads/Analysis/Concepcion2014/holger.zip
% unzip the file and you will have 3 netCDF files with the lidar signals
afile3='sim1_355.nc';
afile5='sim1_532.nc';
afile6='sim1_064.nc';

% have a look at the content of the file, note the variables' names
ncdisp(afile3)

% read the altitude and signals
alt=ncread(afile3,'Altitude');
signal355=ncread(afile3,'Signal');
signal532=ncread(afile5,'Signal');
signal1064=ncread(afile6,'Signal');

% IMPORTANT
% You need to apply the corrections for your lidar data! Example:
% overlap correction, removal of background that varies with altitude
% (black telescope test), etc.

% make a initial picture with signal x alt
figure(1); clf
plot(signal355, alt*1e-3)
xlabel('signal [a.u.]')
ylabel('altitude (km)')

% a second picture, now for log(P*r^2)
% include the 3 wavelengths
figure(2); clf
hold on; grid on; box on
plot(log(signal355.*alt.*alt),alt*1e-3,'b')
plot(log(signal532.*alt.*alt),alt*1e-3,'g')
plot(log(signal1064.*alt.*alt),alt*1e-3,'m')
xlabel('Log Range Corrected Signal [a.u.]')
ylabel('altitude (km)')

% Read Temperature and Pressure data
% For this example, please download the file below (replace the one in the
% ZIP file). It has been formatted properly.  Separator is TAB (i.e. '\t'), and there
% are only 6 columns
```

```
% http://lalinet.org/uploads/Analysis/Concepcion2014/Solut355.txt

%NOTE: most likely your source of meteorological information will not give you
% the same vertical levels (altitudes) that you have in your lidar data. Because
% this is an example, all our files have 1005 levels at the same altitude. So
% remember to interpolate your meteorological data to your lidar-levels.

radio='Solut355.txt';
meteo=dlmread(radio,'\t',3,0);

% last column has altitude (m)
meteo_alt=meteo(:,6);

% first column is pressure in hPa (we need in Pa)
pres=meteo(:,1)*100.;

% second column has temperature in degC (we need in K)
temp=meteo(:,2) + 273.15;

% make plots of pressure and temperature
figure(3); clf
plot(pres, meteo_alt*1.e-3, 'o-')
xlabel('presure [Pa]')
ylabel('alt [km]')

figure(4); clf
plot(temp, meteo_alt*1.e-3, 'o-')
xlabel('temperature [K]')
ylabel('alt [km]')

% Lets run the function that calculates the molecular scattering
% To do this, you should edit the file fernald_new1.m
% Cut the function, and save it with in a different file called alphabeta.m

% lets do for 355nm
lambda=355.e-9; % function expects in meters
co2=400.; % function expects CO2 concentration in PPMV
[alpha_mol,beta_mol,LR_mol,Constants]=alphabeta(pres,temp,lambda,co2);

% plot molecular extinction and backscatter
figure(5); clf
plot(alpha_mol*1.e6, meteo_alt*1.e-3, 'o-')
xlabel('alpha molecular [1/Mm]')
ylabel('alt [km]')

figure(6); clf
plot(beta_mol*1.e6, meteo_alt*1.e-3, 'o-')
xlabel('beta molecular [1/Mm 1/sr]')
ylabel('alt [km]')
```

```
% built the simulated molecular signal

model = (beta_mol .* exp(-2*cumtrapz(meteo_alt,alpha_mol)))./meteo_alt.^2;

% Our lidar signal is perfect (simulated). There is no background or noise.
% You can add some by uncommenting the lines below.

%bg=1e2;
%signal355 = signal355 + bg;
%signal355 = poissrnd(signal355);

% Now plot the molecular reference together with our lidar signal

figure(7); clf
semilogx(model.*meteo_alt.*meteo_alt, meteo_alt*1e-3,'s')
hold on; grid on; box on
semilogx((signal355-bg).*alt.*alt, alt*1e-3,'r-')

% You will notice that the two signal are VERY different
% The problem is the calibration of the simulated molecular reference.

% Looking at the plot, you can realize that above 4km there are no aerosols.
% Let's do the molecular calibration manually, just to learn

figure(8); clf
plot(model(270:end), signal355(270:end), 'o')
xlabel('model molecular')
ylabel('measured signal')
grid on

% make a fit to get the calibration coefficient
tmp=fit(model(270:end), signal355(270:end), 'poly1');
calib=tmp.p1;
hold on; plot(tmp)

% now update figure 7 with the calibrated molecular signal
figure(7)
semilogx(model.*meteo_alt.*meteo_alt*calib, meteo_alt*1e-3,'g-')



% Now that everything is working, go on and run the Fernald code
% You need to input the range of altitude of molecular reference
% You also need the Lidar Ratio

zref=[6.e3 14.e3]; % meters
LR=28. % sr
```

```
[beta_par,alpha_par,LR_par,model_mol,ab_fit]=...
   fernald_new1(alt,signal355, zref,lambda,LR,pres,temp);

% make a plot of the back scatter
figure(9); clf;
hold on; grid on; box on

plot(beta_par.aer*1e6, alt*1e-3,'-b')
plot(beta_par.mol*1e6, alt*1e-3,'-m')
plot(beta_par.tot*1e6, alt*1e-3,'-r')
xlabel('beta [1/Mm sr]')

xlim([-10 100])
ylim([0 10])

% end
```