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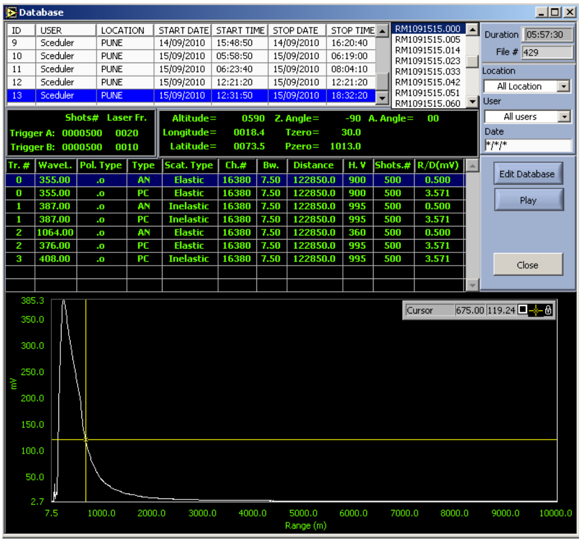
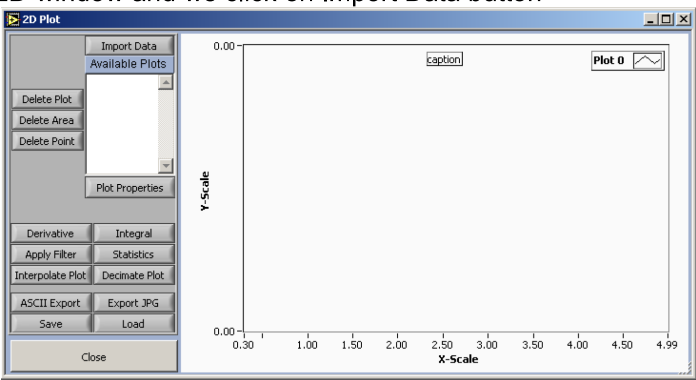
Example of Software Procedure

First of all we have to select a set of measurements with relative clear atmosphere.
We open the Preview DB window and we try to locate such a measurement.

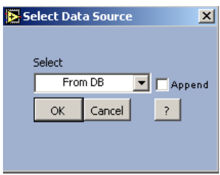


For this example we will use the measurement 13 (Location Pune, India, Start Time 12:31:50, Stop Time 18:32:20 – 15/9/2011). By looking at Raw Data Files, we can see that the measurements between 15:00:00 and 15:04:00 look clear without clouds (at least for the first 10000 meters). We are going to use this set of measurements to check the alignment. These 6 files correspond to a measurement of 6 x 500 = 3000 laser shots which means about 5 minutes averaging.

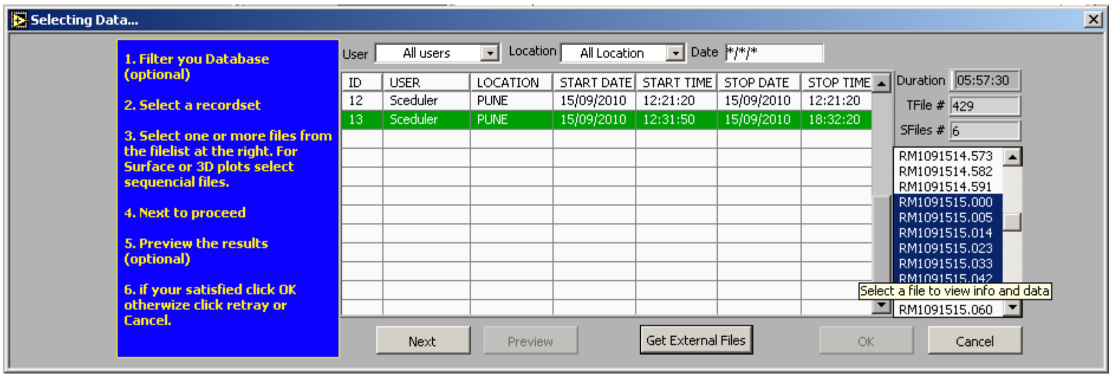
Then we open a 2D window and we click on Import Data button



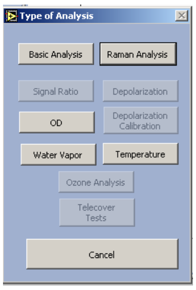
A new dialog box appears which ask to select the source of data files. We select the option “From DB” and we click “OK” button



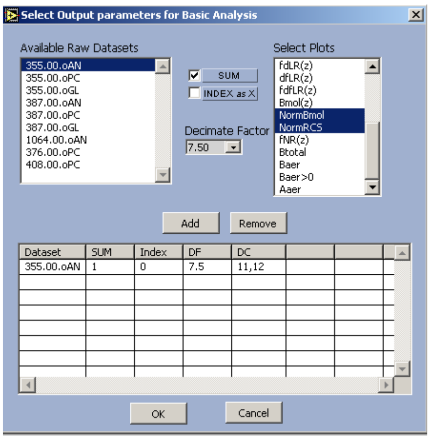
After clicking “OK” a new window will appear where we have to select the raw data files that we want to work with them.



We locate the recordset 13 and then we select all the data files between 15:00:00 and 15:04:00 by using <shift> key. After selecting all the desired sequential data files we click on the "Next" button.

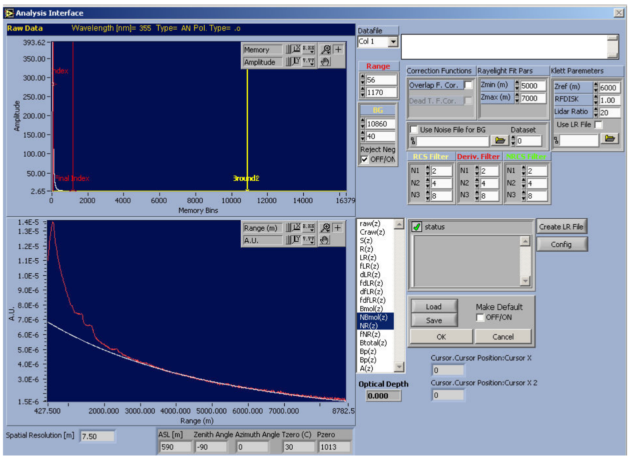


Then click on the "Basic Analysis" button in the "Type of Analysis" dialog box.

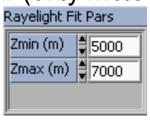


After that we have to select which dataset we like to work with and which results we want to plot at the 2D window.

For checking the aligment we always have to use an elastic backsatter signal. In this case we will select and analog signal of the 355 channel. (355.00.oAN). Then we will ask from software to averaging all the previously selected datafiles. We do that by click the Sum check box. Then we select (by using <shift> key and clicking) the NormBmol and NormRCS options (look at the Theory Section below) to plot at the 2D window. Finally we click on the Add button and we click on the OK button.

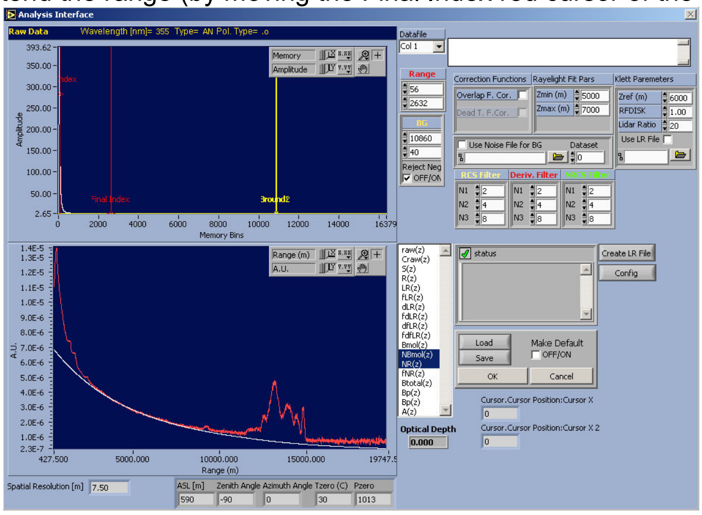


If we assume that the atmosphere is clear (only molecular) between 5000 and 7000



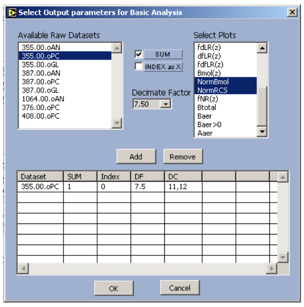
meters we check the alignment by selecting the NBmol(z) and NR(z) paremetes to be plotted at the lower graph window. As we can see there is a good fit between the normalized range corrected lidar signal [NR(z), red plot) and the normalized molecular atmosphere [NBmol(z), white plot].

However if we extend the range (by moving the Final Index red cursor of the top graph),

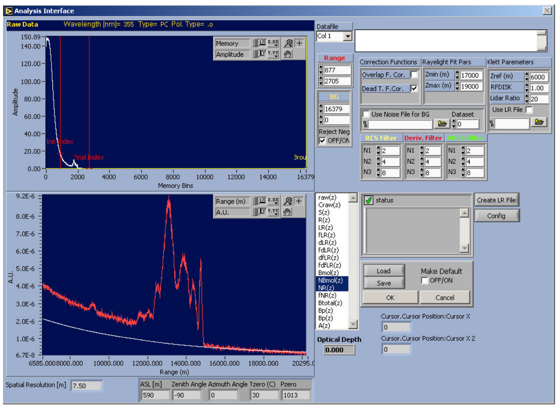


We can observe that the molecular atmposhere does not fit to the lidar signal all the way up to 20000 m as it should do.
These behaviour is due to two facts.
First we can see that the atmosphere is not clear between 9000 to 15000 (We can clearly distinguish aerosol structures at these altitudes) and second because the analog signal that we have selected is not valid above 7000 to 9000 meters.
In general we trust the analog signals only up to 7000 to 9000 meters. After that ranges (altitudes) the signal to noise ratio of analog signals are not good and this is why we have to look and work with photon counting signals for far fields.

We will follow the same procedure but now instead of choosing analog dataset (355.00.oAN) we will select Photon Counting dataset (355.00.0PC)

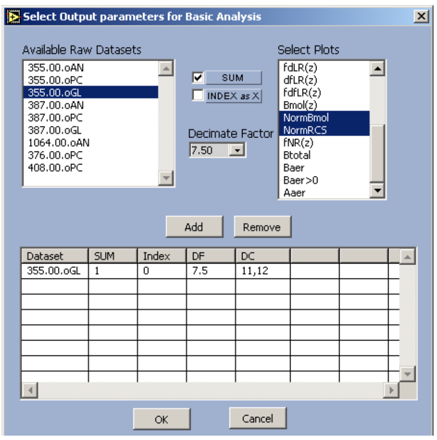


As we can see from the image below now we can assume a clear (molecular) atmosphere from 17000 up to 19000 meters and we can observe that the fit is good at that altitudes. Which means that the lidar is very well aligned and the elastic backscatter data can be used up to 20 Km even with only 5 minutes averaging.



However as we already know we do not trust photon counting data for altitudes less than 4000 to 5000 meters. If we would like to take a look for all the profile (from near field up to far field) we have to use Gluing technology.

So as the last example we will use the Glue dataset instead of analog or Photon Counting data. We have to follow the same procedure but now we will select
Glue dataset (355.00.0Gl)



If we successfully Glue the data (see How to Glue) then we can get all the profile (from near to far field).

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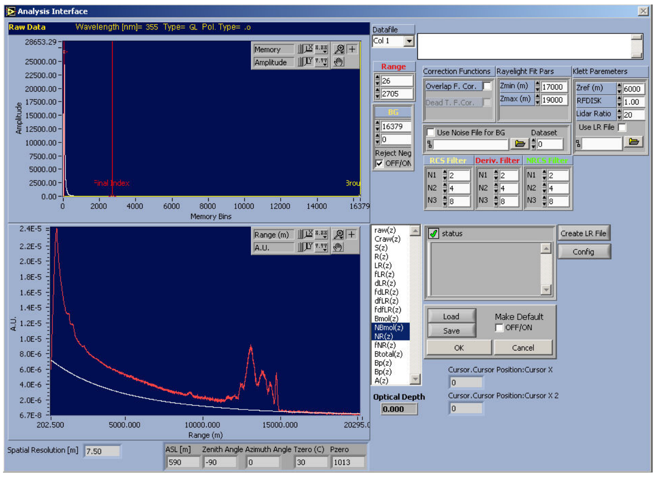

As it can be seen from the image above all the lidar signal is above molecular atmosphere for all the altitudes and fits to molecular from almost 16000 up to 20000 meters.

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Some theory about Alignment Procedures

A lidar user can use to complementary methods to check the alignment status of a lidar system. Both methods are experimental and can performed real time or as post analysis.
First Method:
Signal to noise ratio should be maximum from far field, at a well aligned system.
Second Method:
In a perfect aligned system the molecular signal should fit to the real signal at a part of the atmosphere which is free of aerosols.

Details on second method

The range corrected signal *RCS*= $P_{cor} = P(z)z^2$ is compared with the backscatter coefficient β_{cor} (β_{cor} includes the exponential decay of the signal due to atmospheric extinction)

$$\beta_{cor} = \beta_{Ray} \exp\left(-\int a_{Ray} dz\right) \qquad \text{Eq.1}$$

at a range where we assume that it is free of aerosols so we have only the molecular condribution.

The molecular backscatter and extinction coef (β_{Ray} and a_{Ray}, respectively) calculated by using *U.S. Standard Atmosphere, 1976*]

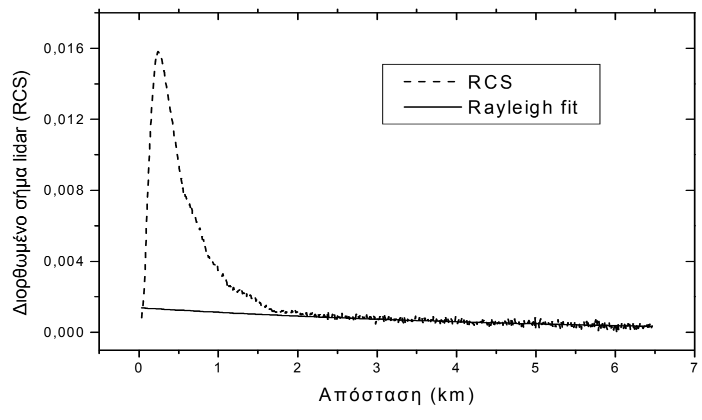

Figure 1
Comparison between *RCS* and β_{cor} in a case of relatively clean atmosphere

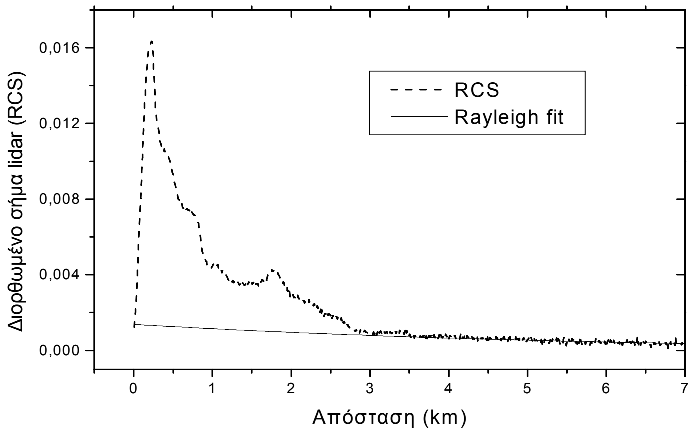

Figure 2
Comparison between *RCS* and β_{cor} in a case of high loads of aerosols

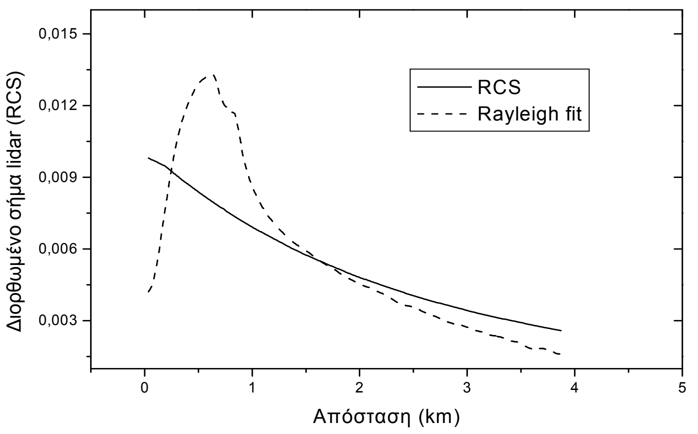

Figure 3
Comparison between *RCS* and β_{cor} in a case of a not well aligned lidar system

Note:
A clear sky without clouds is important for both methods, since in that case the lidar signal extinguish very fast and is not possible to calculate the molecular signal from experimental results.

How software works
NBr(z) is actually the β_{cor} from eq.1.
NR(z) is the normalized Range Corrected Signal

$$NR(z) = RCS(z) * \frac{\sum_{Z1}^{Z2} RCS(z) \Big/ Z_2 - Z_1}{\sum_{Z1}^{Z2} \beta_{cor}(z) \Big/ Z_2 - Z_1}$$

Where Z_2 and Z_1 define a range clear of aerosols

(From Rayleigh Parameters Section: MinR(km), MaxR(km))