# Calibration Procedure for IN100 Nephelometer

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# Procedure for Calibration of the AirPhoton Nephelometer IN100

The calibration of the IN100 nephelometer is a simple routine operation that must be performed often. The required frequency of the calibration depends on the accuracy requirement of each project and must be determined by the user in a case by case basis. The calibration procedure can be performed with the use of two gases with different scattering coefficients. Clean air and CO2 are the two most common gases used in this procedure. We highly recommend the use of high purity clean air provided by a gas supplier but it is also possible to filter the air with a high quality HEPA filter. In this case, it is important to assure that the filter used is effective and does not allow for significant particle contamination. We usually do not recommend the use of industrial compressed air because in many cases this air is contaminated with condensates that can potentially produce artifacts in the calibration and in some cases even contaminate the internal parts of the nephelometer.

The gas flow rate used during the calibration is not particularly important but it should be set in a large enough rate to flush the instrument multiple times during the calibration period and prevent the back flow of particles from the open end of the fan. On the other hand, the flow should be slow enough to minimize internal damage to the instrument due to high pressure, or the production of CO2 ice due to excessive cooling during the gas expansion. In most cases a flow rate between 5 to 15 lpm is enough but we encourage some experimentation to define the best value in each circumstance. The actual value of the flow is not needed to conclude the calibration procedure.

In order to assure the accuracy of the measurements it is important to perform the calibration with the same settings that will be used for the operation of the system during the actual measurements. In particular, special attention should be paid to the variable "*warmwait*" in the config file, which can directly affect the calibration results. If the user wishes to use different values for these (or other) variable in the config file, we recommend empirical testing to be sure that these changes are not affecting your final quantitative result. A simple and safe solution is to calibrate at the desired settings.

To proceed with the gas calibration:

1- Turn off the fan (or pump) in the outlet of the nephelometer by either unplugging the connector or via config file.

2- run nephelometer with high purity clean air or nitrogen for about 15 minutes or until the system is completely flushed with the clean gas.

3- without turning off the system switch to a second gas with higher scattering coefficient ($CO_2$, $SF_6$, etc.) and run it for 15 minutes. Since the $CO_2$ can freeze and produce ice particles, we recommend to add a HEPA filter on the line between the $CO_2$ tank and the instrument.

Run the NephCal.htm program and load the raw output file from the nephelometer being calibrated. Make sure both scripts (NephCal.htm and nephcal_script.js) are in the same directory. The output file can be in any other location. The first screen of the NephCal software is shown in figure 1.

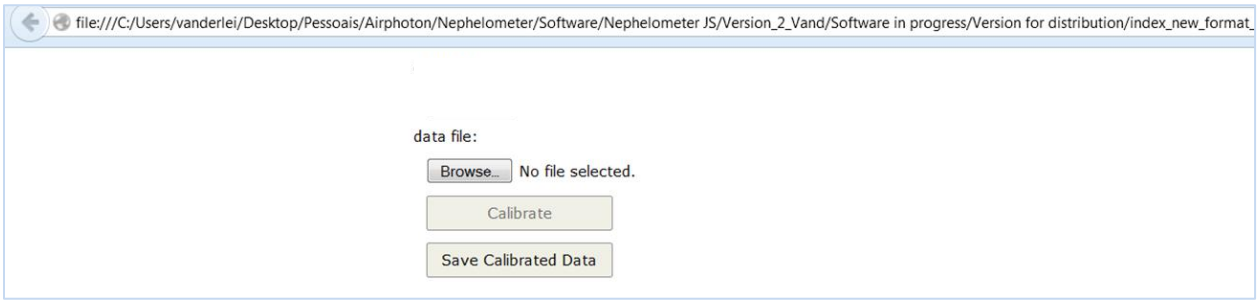


*Figure 1 – initial screen of the NephCal software.*

Browse for the desired input data file. After loading the calibration file, you will see a screen similar to the one illustrated in figure 2.


*Figure 2- Display of the loaded calibration file showing the results for measurements with clean air and CO2. The miscellaneous gauges display shows the internal pressure, relative humidity and temperature of the nephelometer.*

Hit the calibration button and use the scroll bar or the “sensor line” field to determine the begin and end positions of the calibration for each gas. After the scroll bar (or the “sensor line” field) are in the right position, click on the respective button for “Begin Gas” or “End Gas” accordingly. Select the correct calibration gases that you have used to calibrate the nephelometer and hit the perform calibration button.

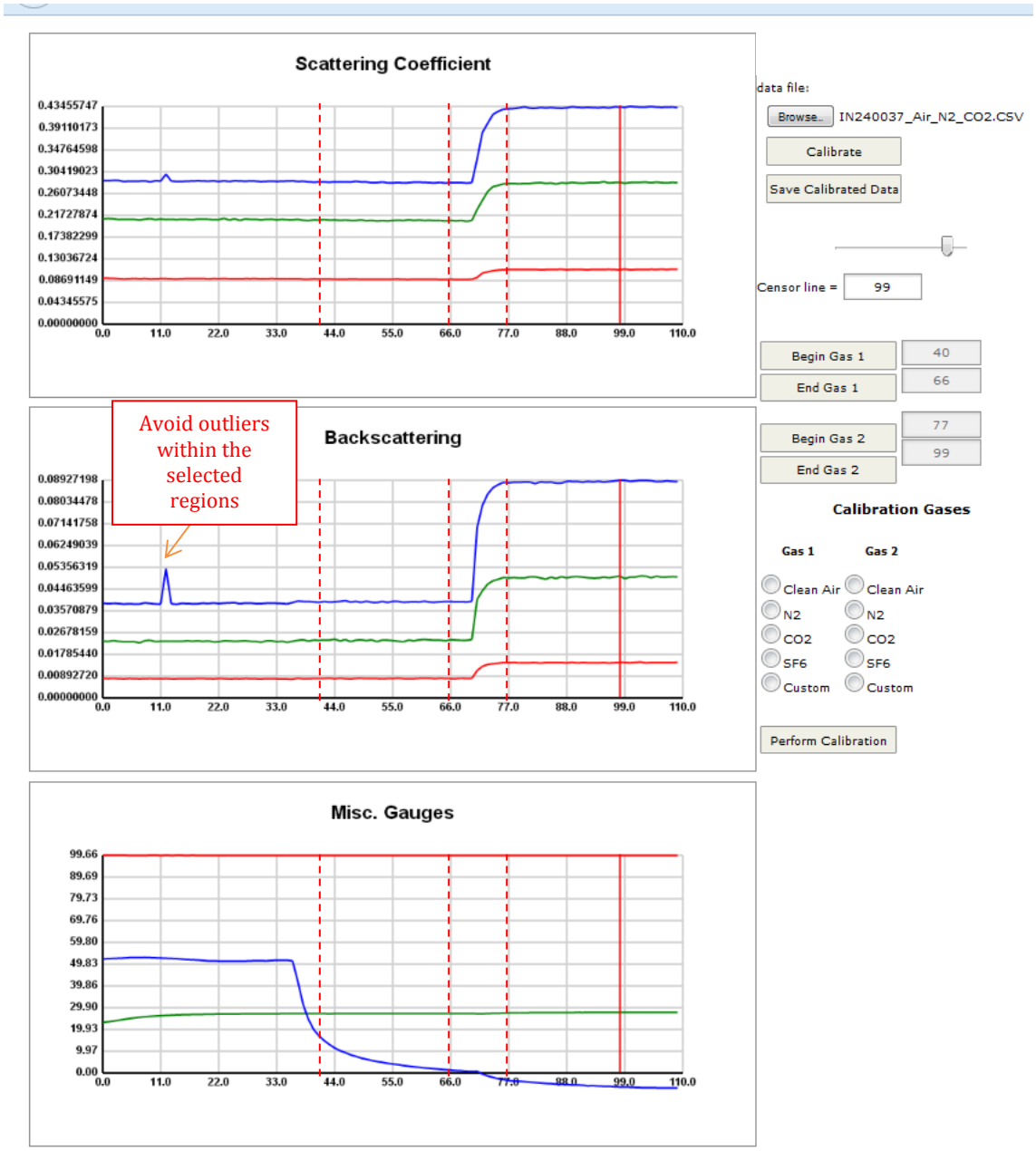


*Figure 3 – Illustration of the procedure to selected the regions of the plots to be used in the gas calibration. Make sure to avoid outliers that can contaminate the calibration as indicated in the plot.*

At this point, the "Perform Calibration" button will open a new screen with a text output file showing the final calibration coefficients to be uploaded to the nephelometer. These results should be copied to the nephelometer SD card in a config.txt text file. This step concludes the quantitative calibration of the nephelometer. Figure 4 illustrates the calibration results.

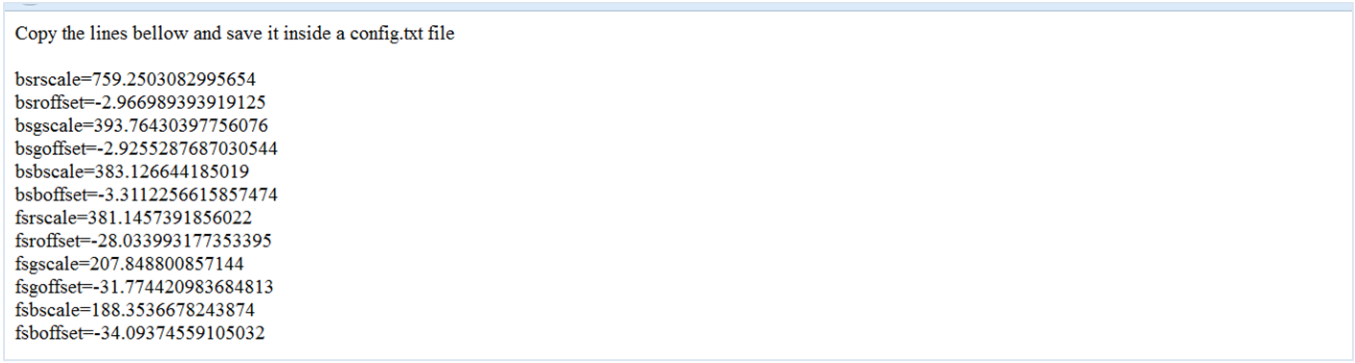


*Figure 4 – New screen showing the results of the current calibration. These coefficients can be copied directly to a config.txt file that will be uploaded to the nephelometer for concluding the quantitative calibration.*

After the calibration is performed, the graphic screen in the initial tab of you browser will display results after the quantitative calibration has been applied and the Rayleigh background has been subtracted. If the used low span gas is “clean air” the values for that portion of the plot should equal zero, as shown in the example on figure 5. At this point the calibration coefficients are also stored in memory in the program and will be applied to any previous raw data file that is opened. The calibrated data will be plotted on the graphic screen as shown in figure 6. The numerical values can also be displayed by clicking the button “Save Calibrated Data”. The final values will be displayed in a new tab and can be copied and pasted to a new data file, spreadsheet or whatever software the user wishes to use. The new calibrated data can also be saved by using the “save” or “save as” option of your browser.

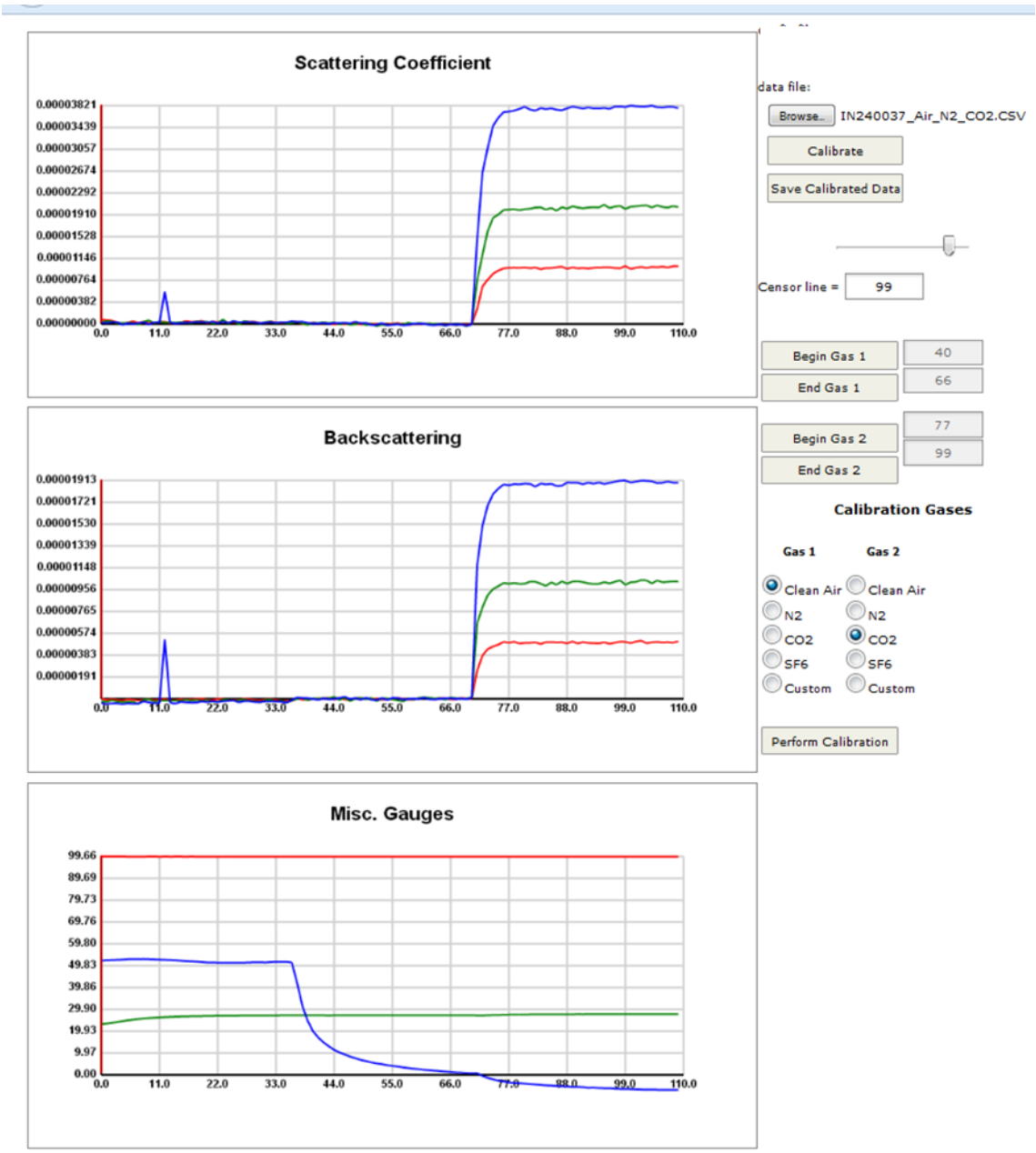


*Figure 5 – Display of the final calibration applied to the original input file. These results include the subtraction of the Rayleigh scattering values from clean air at the measured temperature and pressure.*

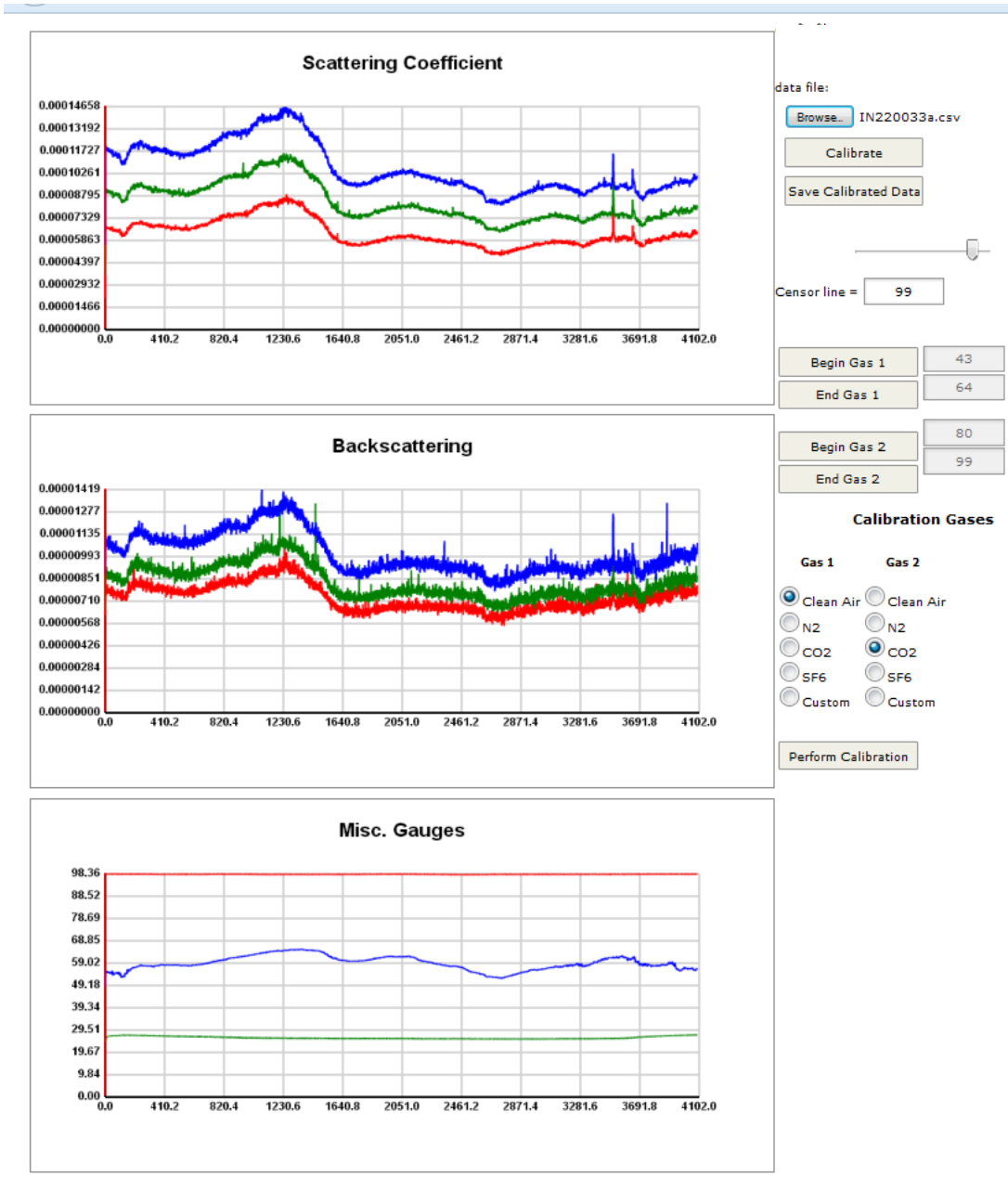


*Figure 6 – Display of the final data after the calibration has been applied.*

# Use of the Convert Software

The Converter program is designed to apply the calibration coefficient to output nephelometer data. Each copy of the program will be assigned to a particular nephelometer and should be updated with the newest calibration coefficients.

The calibration coefficients are obtained with the procedure described above and the final results (as shown in figure 4) should be copied to the beginning of the *Converter_script 1.1.js* file as:

```
//Calibration Coefficients for IN1002
bsrscale=1681.0898172751502
bsroffset=-19.02051352703217
bsgscale=1017.2183904989839
bsgoffset=0.22946992114686676
bsbscale=339.061079556773
bsboffset=-5.086693059222427
fsrscale=980.4970148936349
fsroffset=-47.28918743509982
fsgscale=582.7951012940207
fsgoffset=-23.37276923517977
fsbscale=543.17619153055
fsboffset=-29.554981782416387
//
//Do Not Modify bellow this line.
//Do Not Modify bellow this line.
//Do Not Modify bellow this line.
```

At this point the Converter program is customized for that particular instrument and will take raw input data and convert it to calibrated scattering coefficients. In order to use the program, run the converter_INXXX.htm program and load the raw output file from the nephelometer being calibrated. The INXXXX label indicates a particular nephelometer serial number but it can be applied to a different instrument by simply using the appropriate calibration coefficients for that instrument. Make sure both scripts (*converter_INXXXX.htm* and *converter_script_INXXXX.js*) are in the same directory. The output file can be in any other location. The first screen of the Converter software is shown in figure 7.

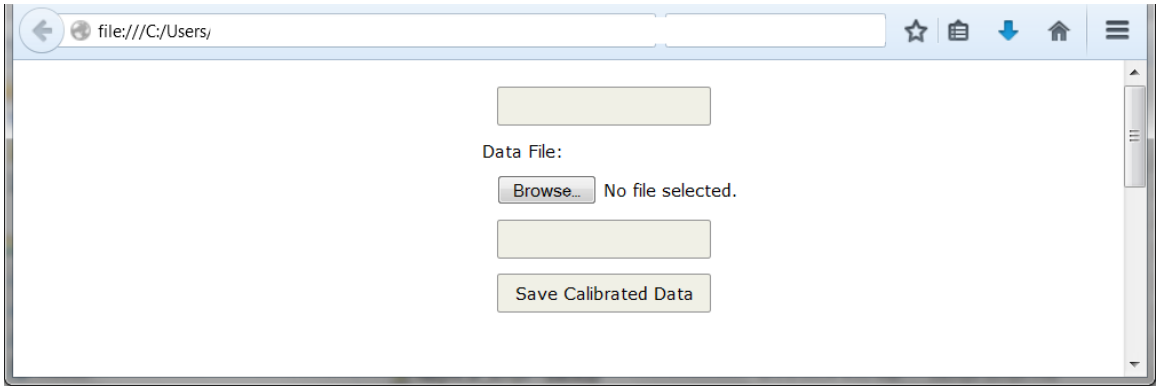

*Figure 7 – initial screen of the Convert software.*

Browse for the desired input data file and load it. After loading the file, you will see a screen similar to the one illustrated in figure 2, with the exception of the *Calibrate* button, which has been removed from this screen. In order to save the calibrated data simply click on the *Save Calibrated Data* button. The "new data" will display in a new browser window and can be either copied and pasted from there or can be saved by using the "save" or "save as" option in your browser.