

OPERATION MANUAL Resonance Mini DOAS Spectrometer

Model # RMD I

March 2006

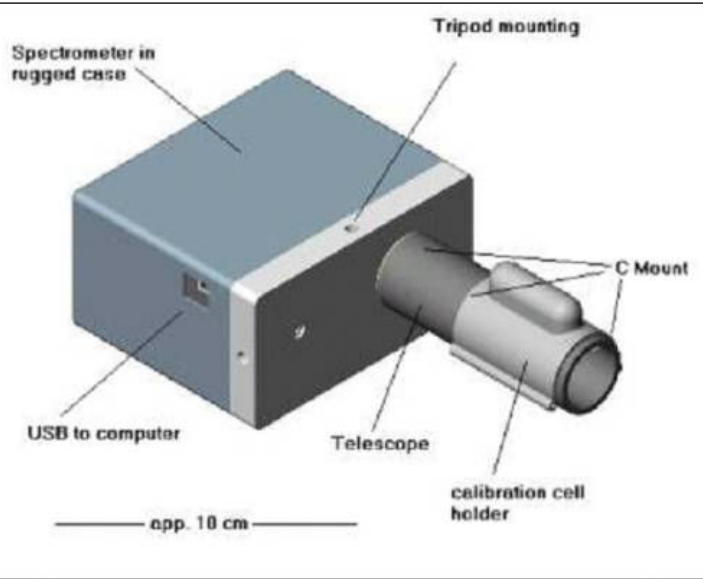


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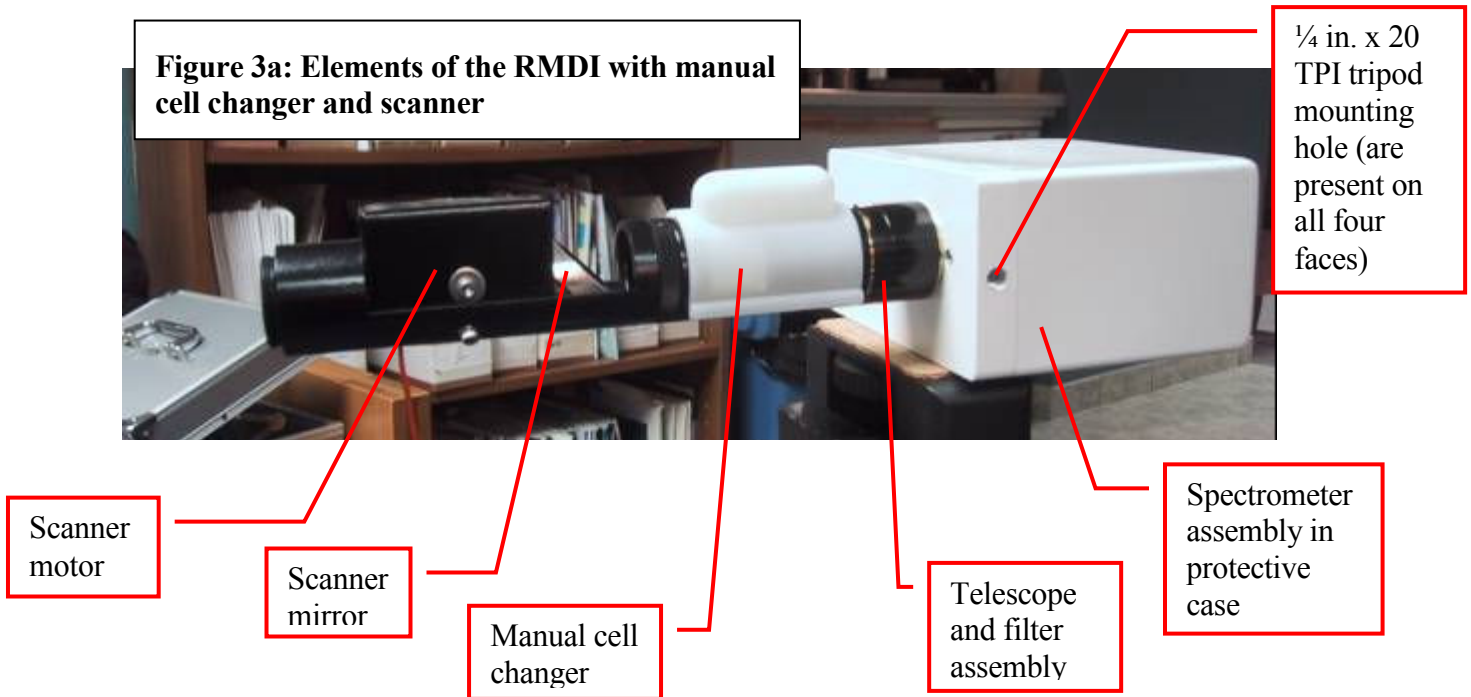
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1. GENERAL INFORMATION

RMDI is a compact UV/visible spectrometer system designed for remote sensing of atmospheric gases. It employs a miniature CCD array spectrometer, which recovers a spectrum from 280 to 420 nm and is small enough to be readily backpacked into remote locations for volcanic plume characterization. RMDI consumes so little energy that it is completely powered by USB connection to a laptop computer. The system, designed for volcanic gas monitoring, is normally supplied with SO₂ and/or NO₂ calibration cells with cell holder, a laptop computer with installed software, calibrations and a miniature tripod.

Analysis software uses a script file compatible with Ocean Optics' OOIBase32 software. RMDI is also compatible with DOASIS University of Heidelberg, which can be downloaded from their website. The figures on the cover page show RMDI with laptop in use at the Tungurahua volcano in Ecuador.

The elements of RMDI optical assembly are shown in Figures 3a and 3b below:



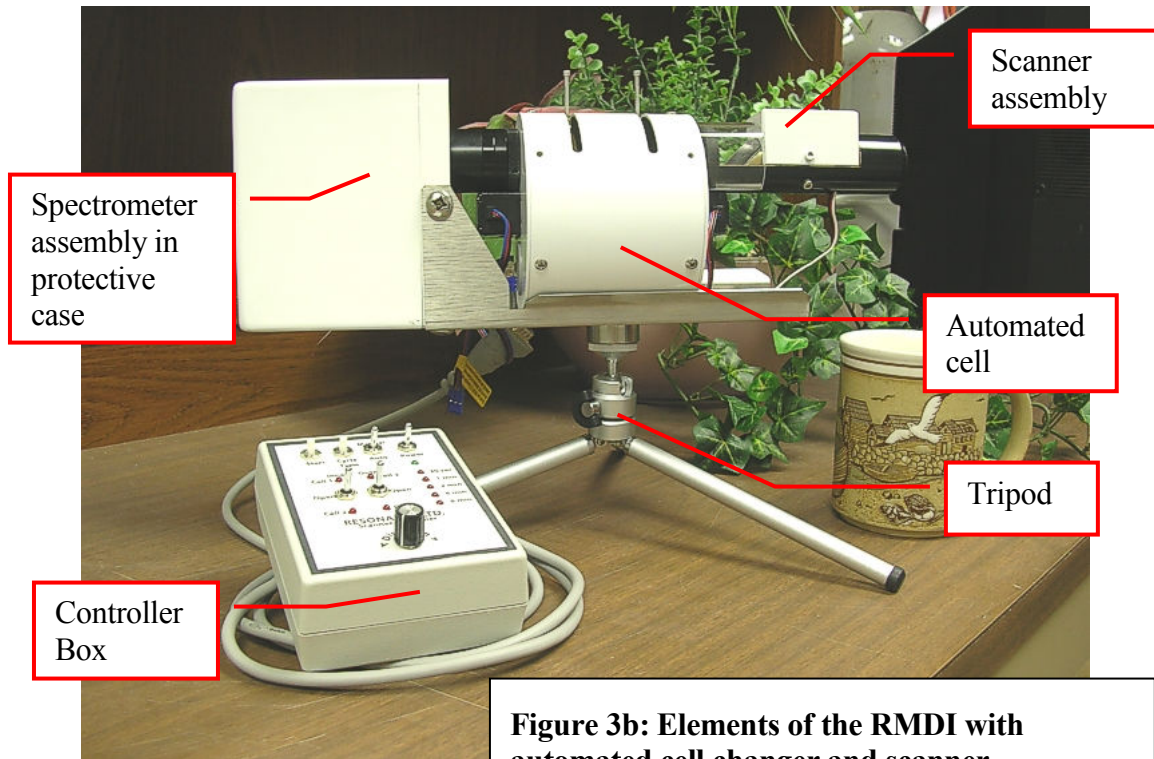


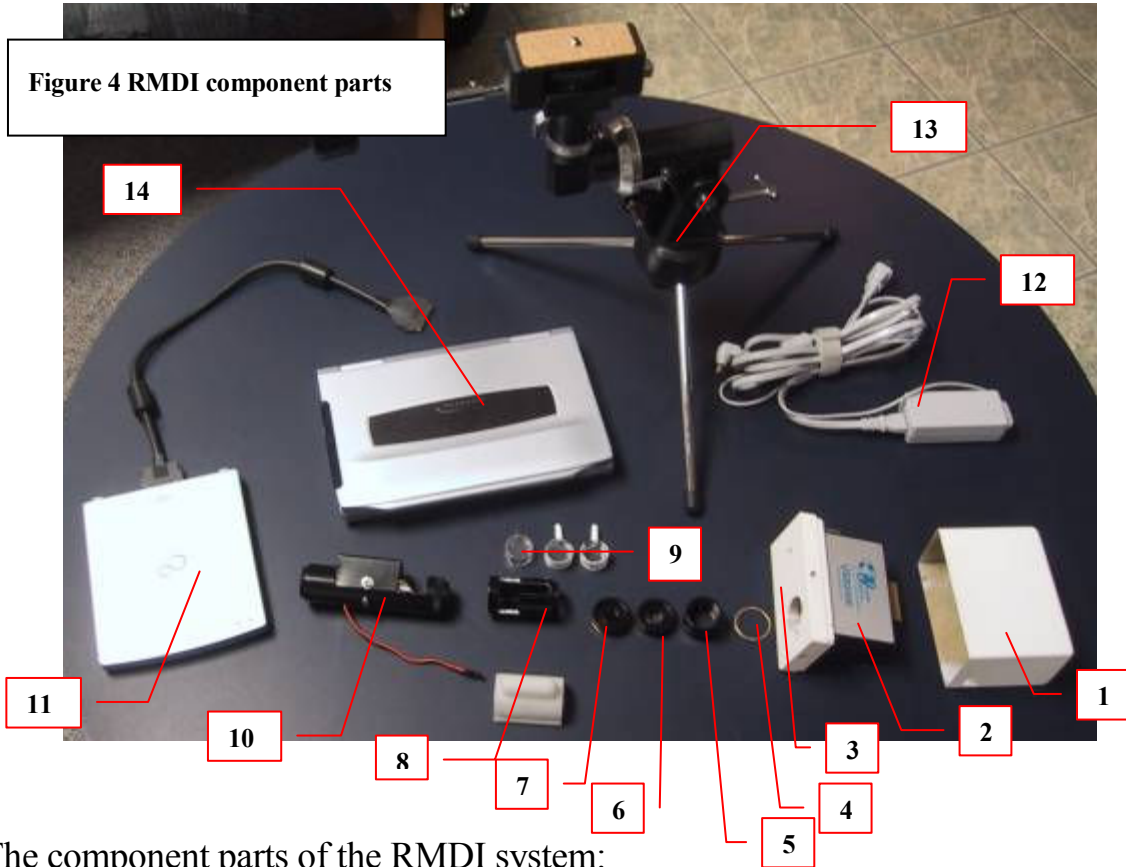
Figure 3b: Elements of the RMDI with automated cell changer and scanner

RMDI can be positioned in any orientation to look directly at the sky along the telescope axis or through a right angle turn using the optional scanner. Four mounting holes in the spectrometer assembly case (Fig. 3a) are provided to attach to any standard lightweight tripod. The optical scanner can also be used to select the look direction with a scanner.

2. SPECIFICATIONS

2.1. Component Parts

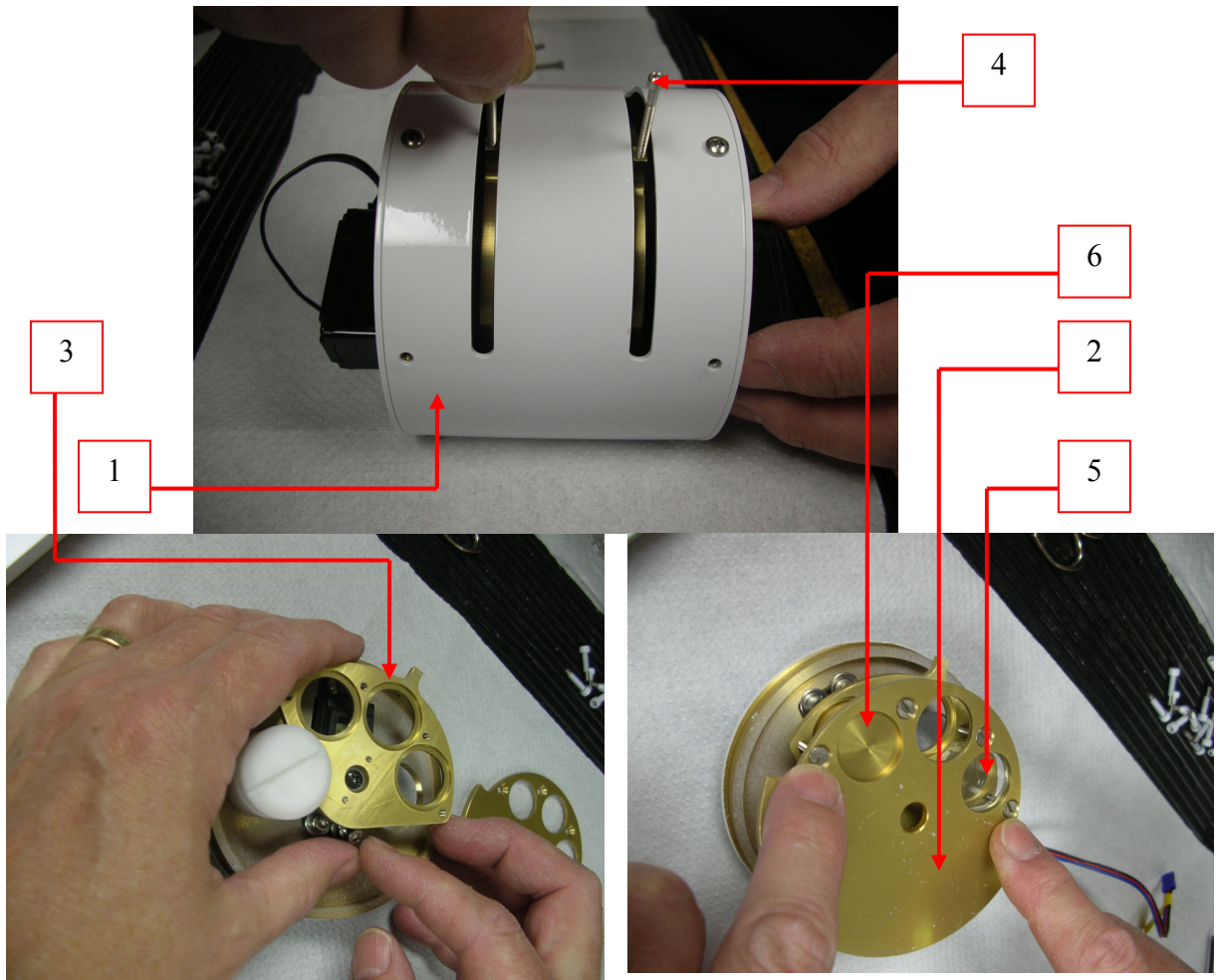
2.1.2. RMDI Components



The component parts of the RMDI system:

- (1) Spectrometer protective housing, **(when used with automated scanner or cell changer, 6 AA batteries are housed inside and can be replaced when necessary)**
- (2) Ocean Optics USB 2000 spectrometer,
- (3) Spectrometer mounting flange,
- (4) Spacer for the telescope tube,
- (5) Telescope tube,
- (6) Telescope lens in C mount holder,
- (7) UV blocking filter in C mount holder **(NOT USED WITH NO₂ CELLS, AS WILL INTERFERE WITH NO₂ SPECTRA)**
- (8) Calibration cell holder and cover
- (9) Calibration cells
- (10) Scanning mirror assembly
- (11) Palmtop computer CD drive
- (12) RMDI palm top computer AC power supply
- (13) RMDI mini tripod
- (14) RMDI palmtop computer.

2.1.2. Cell Changer Components



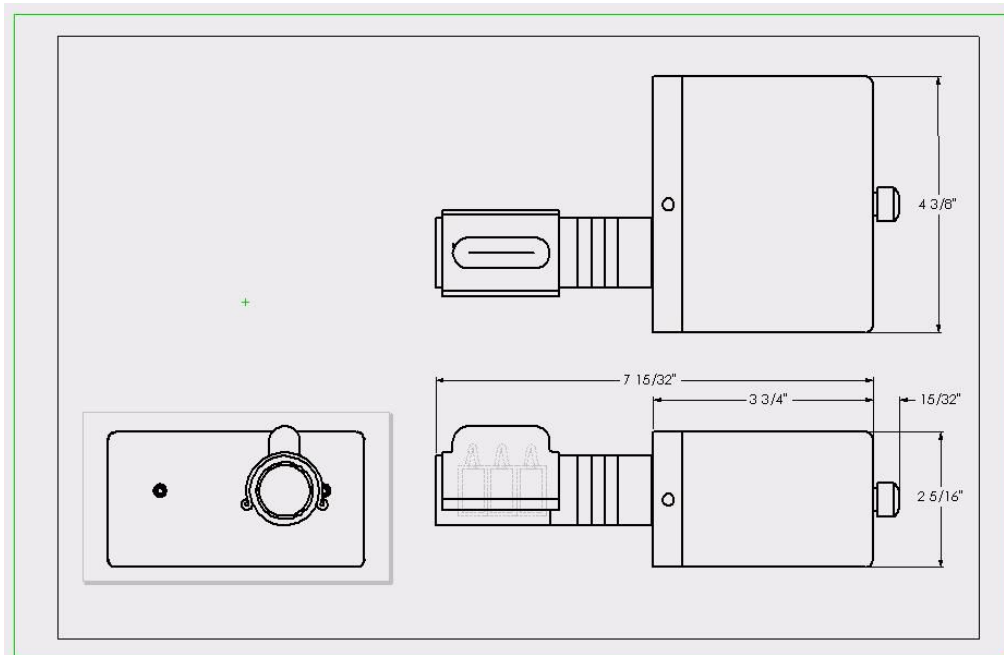
The component parts of the Cell Changer:

- (1) Cylindrical Body
- (2) Cell Face Plates
- (3) Cell Mounts
- (4) Position Indicators
- (5) Cells
- (6) Blanks

2.2. Physical Specifications

Interface to computer	
The spectrometer includes a plug-and-play high-speed analog to digital converter with USB interface to control the linear CCD detector. This interface provides full control of the CCD detector and allows 12-bit data acquisition. It is powered by the USB line and provides all the power and control lines to the CCD detector.	
Dimensions of spectrometer	3.75" w x 4.375" d x 2.3" h (9.5 x 11.1 x 5.8 cm)
Dimensions of telescope with VIS blocking filter and cell holder	3.75 x 1.5 inches
Gas cells supplied with unit	Typically 3 SO ₂ cells allowing 7 points of calibration
Weight	Less than 1 kg (not including laptop)
Tripod	Mini tripod
Tripod interface	4 ¼ 20 tpi threaded blind holes
Interface Cable	USB cable (can be 5 meters long)
Power requirements	Draws 0.45 W power from PC through USB
Software supplied	OOIBase32 (Ocean Optics), OO Script (Resonance)
Available software	DOASIS from U of Heidelberg (freeware download)

2.3. Mechanical Drawing



2.4. Electrical Specifications

Electrical /Optical Specifications:				
Specification	Min	Typ	Max	Units
Standard Telescope field of view	-	2	-	degrees
Spectral resolution	-	0.4	-	nm
Sensitivity for SO ₂ (zenith sky 1 sec.)	5 (noon)	10	30 (twilight)	ppm-m
Spectral range 2400 l/mm gtg (with visible spectrum blocking filter)	-	295 to 380	-	nm
Spectral. range 2400 l/mm gtg (no filter)	-	295 to 437	-	nm
Integration time	0.03	0.1	10	seconds
Sensitivity	-	90	-	Photons per A/D count
Full scale	-	4095	-	A/D counts
Max.signal to noise for one average	-	250	-	-
Dark noise	-	2.5	-	RMS counts
Corrected linearity	-	99.8	-	%

3. GETTING STARTED

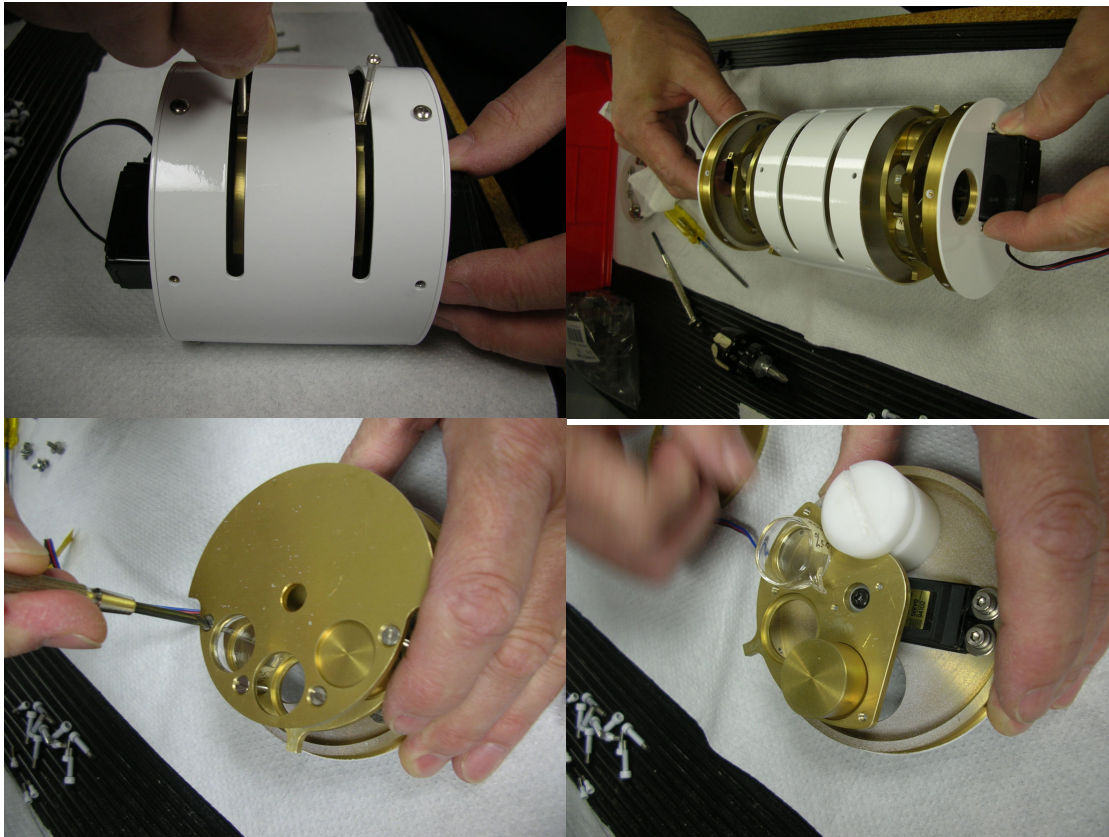
3.1. Assembly of RMDI

Assembly of RMDI is carried out by first securing the spectrometer protective housing onto the spectrometer with the rear captive nut. The telescope and calibration subassembly can be assembled by carefully screwing parts (5), (6), (7) and (8) together. If you have purchased a Cell Changer, it takes the place of part (8) cell holder. Read section 3.2. for instructions on assembly/disassembly of the Cell Changer. Once this is assembled it can be attached to the spectrometer mounting flange (3) by placing the spacer rings (4) over the threaded projection and gently screwing the assembly into the mounting flange (3). **If the threaded pieces bind or jam during threading process do not force threads. The piece may be loosened by applying about 10 drops of isopropyl alcohol to the bottom of the thread. After capillary action has drawn the liquid up into the thread the piece may be unscrewed.**

Depending on the orientation of RMDI it may be desirable to rotate the calibration cell holder (8) so that the slot for the cells faces upwards. Spacers can be inserted to allow one to lock the assembly in this orientation (spacers are provided to allow orientation of the slot facing upwards on RMDI set up on a typical tripod). Once the scanner assembly is coupled to the telescope the whole RMDI assembly can be coupled to the tripod.

Connecting RMDI to the electronics involves plugging the USB cable into the computer and into the USB connector receptacle on the small face of the RMDI protective cover, as well as plugging the flying lead into the scanner controller hand module.

3.2. Disassembly of Cell Changer



- i. Remove the cell position indicating screws.
- ii. Remove the screws from the cylindrical body of the cell changer.
- iii. Carefully remove each end of the cell changer from the cylindrical body.
- iv. Remove the screws from each cell face plate. Carefully remove the face plate.
- v. When placing a cell in a selected holder, note which cell position holds which cell and arrange them radially so that the cell-stem points toward the axis of rotation.
- vi. When all cells and blanks have been placed, replace the cell face plate and fasten into place.
- vii. Replace the ends into the cylindrical body and replace all screws.
- viii. Attach the cell changer to the front of the RMDI between the UV blocking filter (Figure 4, part 7) and scanning mirror assembly (Figure 4, part 10).
- ix. Connect electrical leads to the Scanner Controller box.

3.3. Checking for spectrometer/spectral acquisition functionality

To verify the function of RMDI:

Plug the RMDI USB cable into the computer and RMDI then start the Ocean Optics OOIBase32 program. This program is delivered with extensive help files, which serve as an instruction manual for operation. After about a minute the program will be ready for acquiring the spectrum.

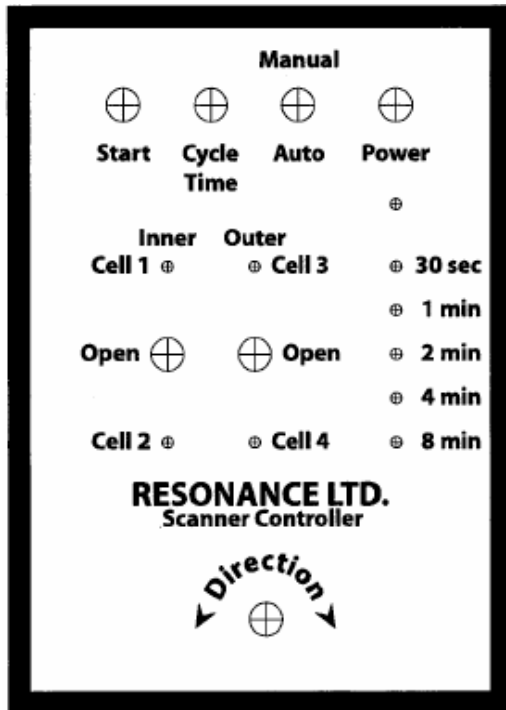
A quick way to verify operation is to point the spectrometer at a fluorescent light and view the spectrum. The spectrum should be similar to the illustration below (although the peaks might be at different heights).



4. OPERATING THE SCANNER CONTROL BOX

4.1. Standard Operation

The scanner provides a selectable scan rate of 120 degrees in 30 seconds, 1 min, 2 min, 4 min and 8 min intervals. The front panel of the scanner controller is pictured below (with cell changer option):



To scan automatically:

1. Set manual/auto switch to Auto.
2. Switch on power.
3. Select speed using cycle time button.
4. LED will light up next to speed selected.
5. Press start button to scan.
6. Scanner will begin immediately to scan back and forth.
7. To change speed switch off power and repeat 1 to 6.

To manually select mirror position:

1. Set manual/auto switch to Manual.
2. Switch on power.
3. Set mirror position with direction dial

4.2. Operation With Cell Changer

Before operating the scanner with cell changer, the set-up process must be performed. This set-up process is performed at the factory, however, it may become misaligned during shipment, at which point this procedure would be necessary. Misalignment can be seen by observing the position indicating screws and noting if they are aligned within 1mm of each other, at the center top of the cylindrical body:

Set-up Process:

1. Depress and hold down the cycle time switch
2. Turn on the power.
3. After 5 seconds, release the cycle time switch.
4. Using the direction knob, set the cell holder to center a clear hole (open cell) in the light path. Use the position indicating screw as a guide.
5. Press and release the cycle time switch.
6. Repeat steps 4 and 5 for the second open cell.
7. Press and release the cycle time switch.
8. Switch off the power.
9. Switch on the power to begin normal operation.

Normal Operation:

1. Set manual/auto switch to Auto.
2. Switch on power.
3. Press start button.
4. Select cell position by toggling switches to Cell 1, 2, 3, 4, Open or any combination.

To manually select cell position:

1. Set manual/auto switch to Manual.
2. Switch on power.
3. Use the position indicating screws to push the cells into place.

5. OPERATING THE SPECTROMETER WITH SOFTWARE

The operation of the RMDI requires the installation of the Ocean Optics and Resonance software. This is pre-installed and ready for operation.

5.1. Operating with Resonance Supplied Script File

Resonance provides a Sax Basic Script file for calculation, display and acquisition of SO₂ and/or NO₂ data.

Introductory Notes:

The following script processes spectral data for RMDI and RMD-2 and saves SO₂ readings to C:\DefaultSO₂Data.txt. Stopping then re-starting the script file will append data to the file. Each time the script file is started, a header block with information about the spectrometer is also appended to the file.

Changing this filename will save the data to a different disk location. For example, the filename "C:\Documents and Settings\Bill Smith\Desktop\DefaultSO₂Data.txt" would save data to a file on the desktop for the computer named Bill Smith.

If real time SO₂ ppm-m readings are required, make sure the variable HiCalActual (in the script file) is set to the High cal cell calibration value (in ppm-m). If the High Cal is changed, modify the variable and re-save the script file.

Example: assign the value of the cell used as the High Cell in your field calibrations to the variable HiCalActual

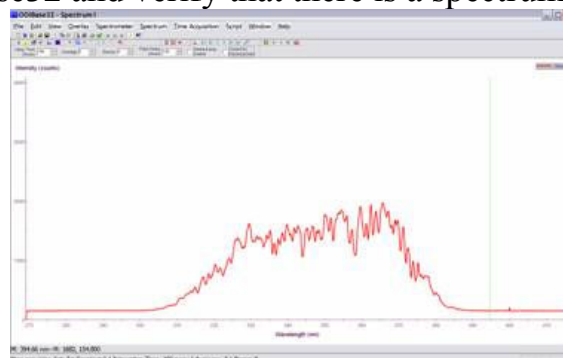
$$\text{HiCalActual} = 1245$$

This version of the software enables the user to set the zero and span in the field. This is necessary only if one wants to get accurate readings of SO₂ from the computer display. Otherwise, the data can be analyzed at a later date by comparing the signals in the file to SO₂ calibration cell signals. Zero is set by pointing at a clear sky, waiting 10 seconds and pressing “0” (number 0). Span is set by pressing “1” 10 seconds after putting the high cal SO₂ cell in the optical path (while still pointing away from the plume). For the best results, this zero span operation is carried out before and after scanning through or driving/flying under the plume.

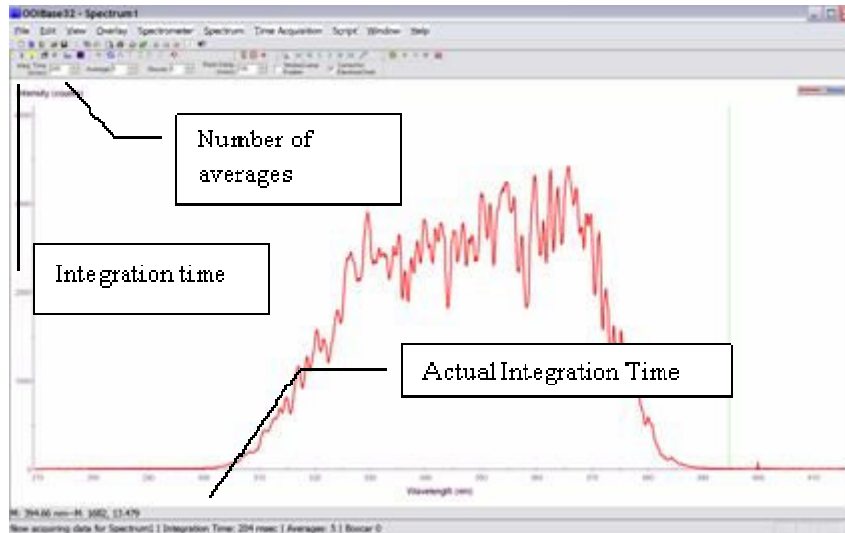
The time series trace then displays actual ppm-m of SO₂. The y-axis scale does double duty as the y-axis for the SO₂ column in ppm-m and the spectrum scale in intensity counts.

To operate this script:

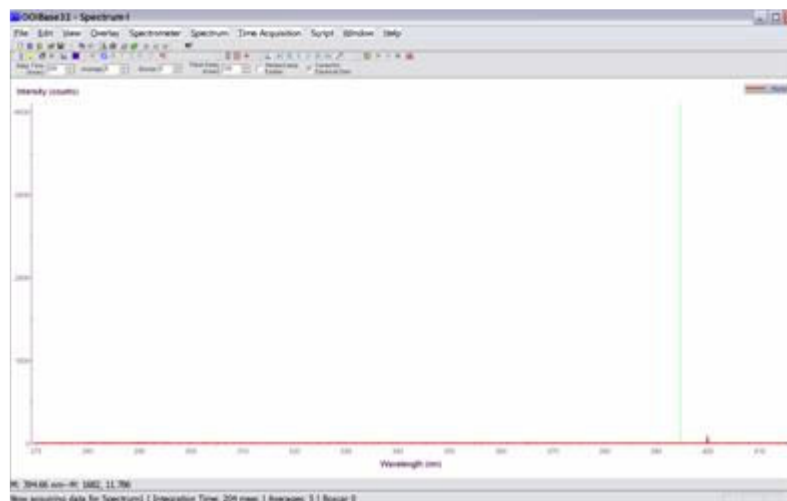
1. Plug in the spectrometer to the computer USB port
2. Point RMDI at the zenith sky or part of the sky away from the plume
3. Start OOIBase32 and verify that there is a spectrum



4. Select correct for electrical dark
5. Go to Spectrum Configure Data Acquisition
6. Set integration time so that the highest spectral intensity is about 2/3 of the scale (The integration time (IT) will be between 50 and 500 milliseconds under most conditions). Set averages so that IT x averages is between 500 and 1,000 milliseconds. In the example below the actual sampling time is $204 \times 5 = 1020$ milliseconds.

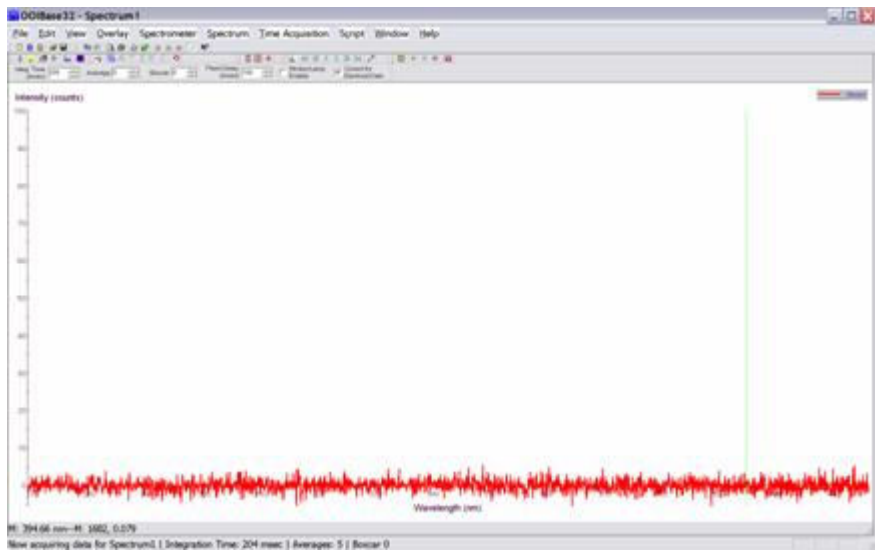


7. Block off RMDI's telescope aperture or set the auto cell changer to closed or zero position.

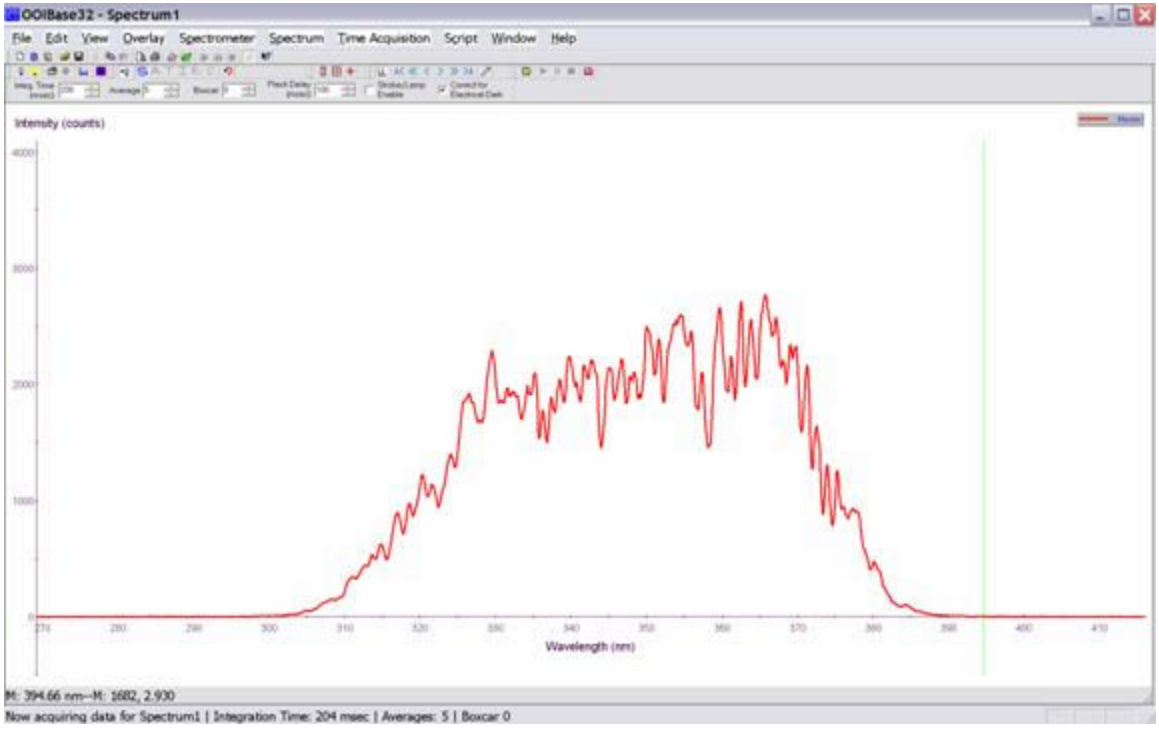


8. Click on dark light bulb to record the dark level

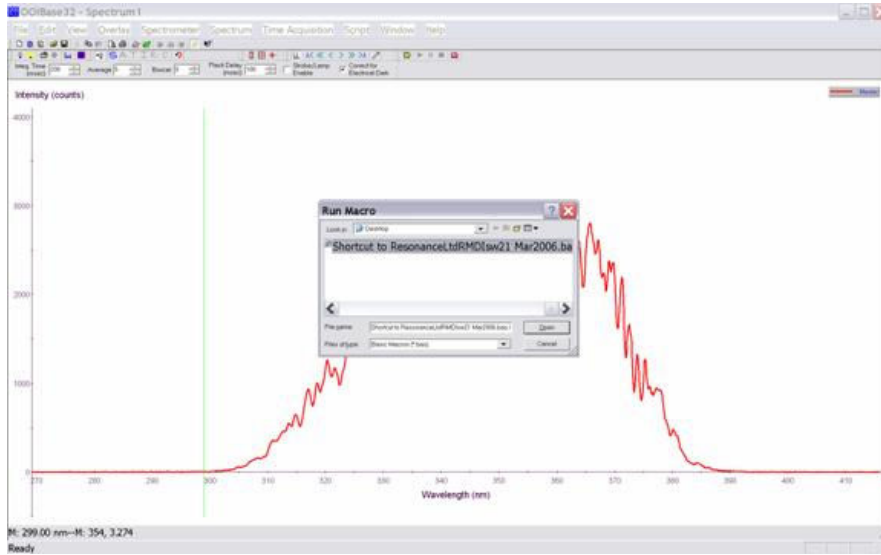
9. Click on the light bulb with a bar to left to select the spectrum mode with dark subtraction. The typical dark noise level at 200 msec x 5 averages is shown below:



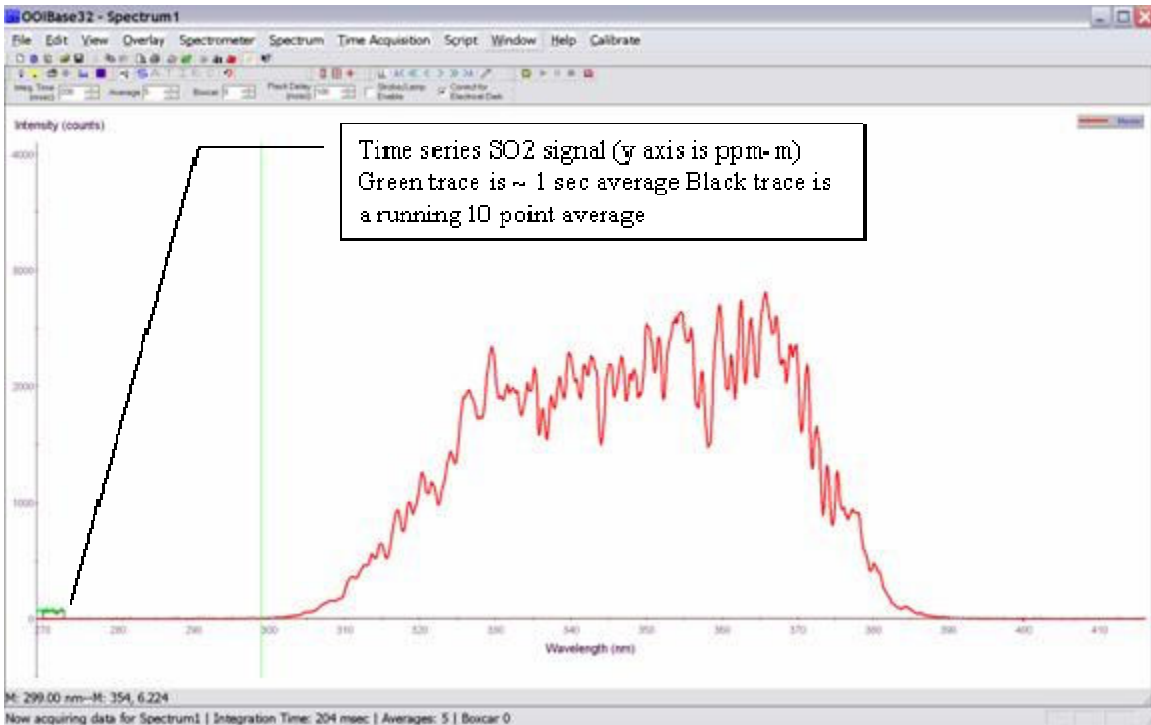
10. Stop blocking the aperture and/or switch auto cell changer to the fully open position



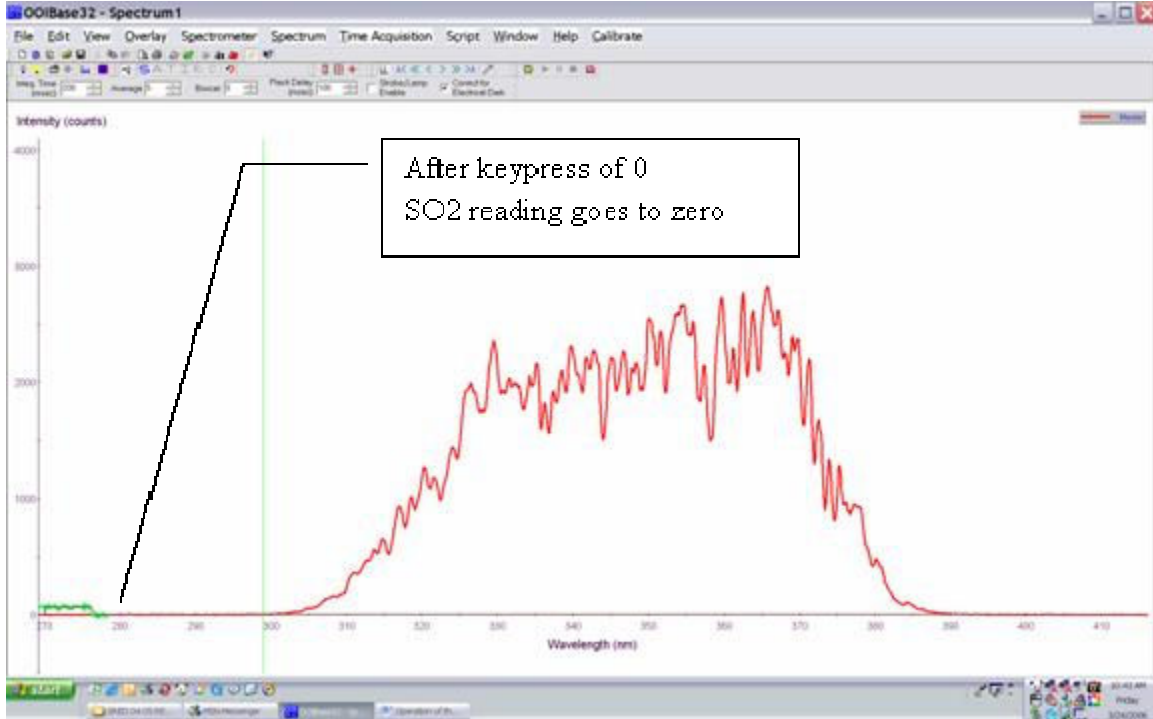
11. Using the Script Menu run the script file “ResonanceLtdRMDIsw21 Mar2006”



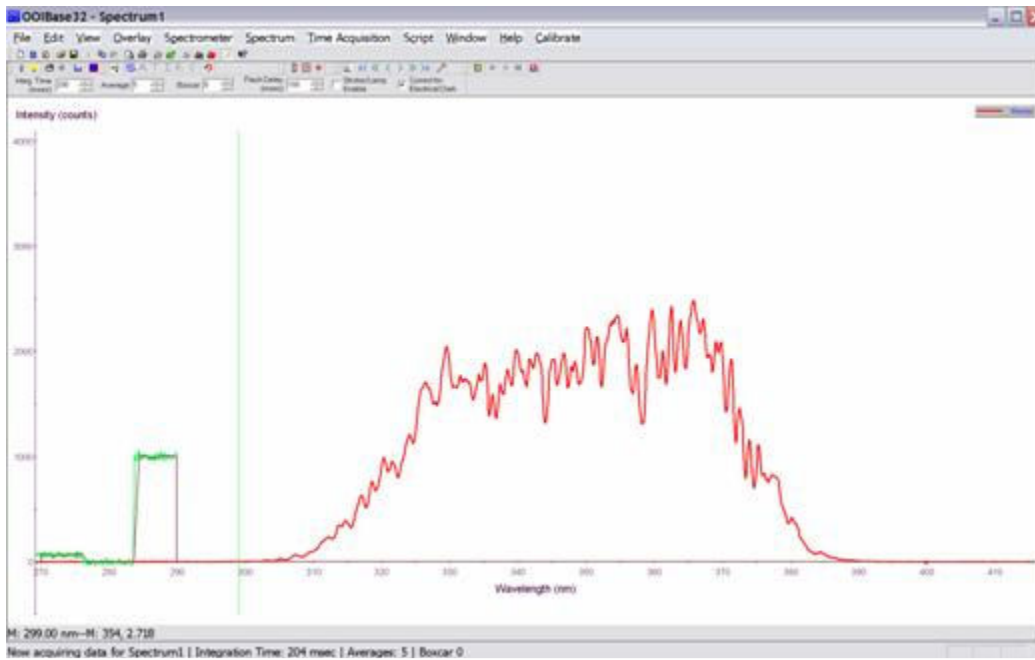
12. The trace which represents the RMDI SO2 signal will be seen on the left hand side of the spectrum window. This trace uses the x axis scale of the spectrum as a time axis. After 10 seconds a second trace will appear. This trace is a 10 sample running average of the SO2 signal.



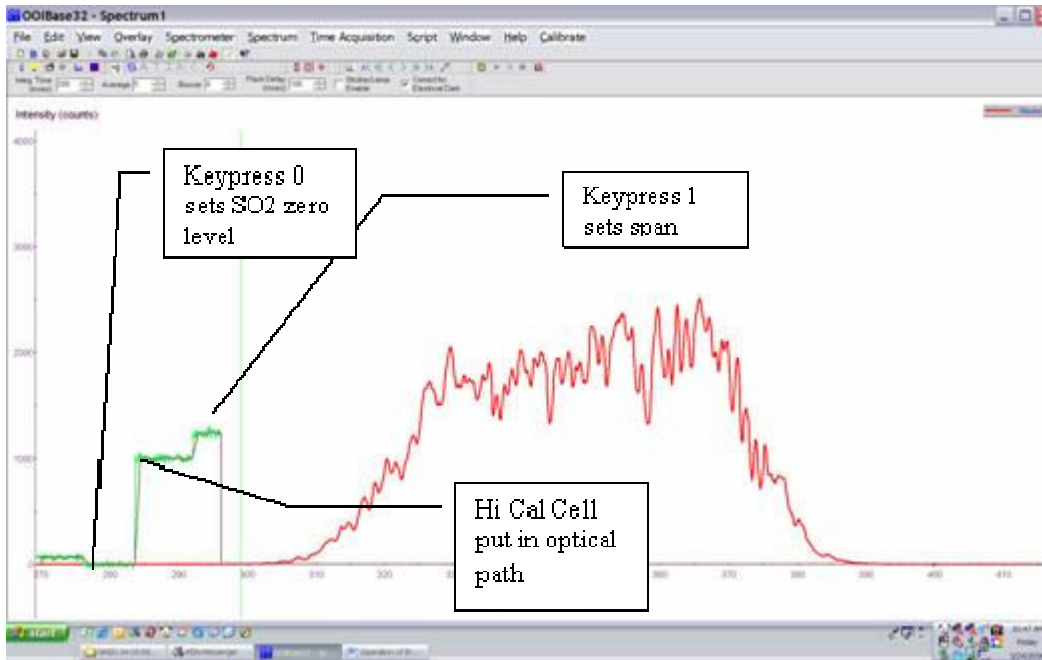
13. Once the average trace is level, press “0” (zero) on the computer keyboard. The traces should move to zero in about 10 seconds. If zero is not obtained after 10 seconds hit zero again.



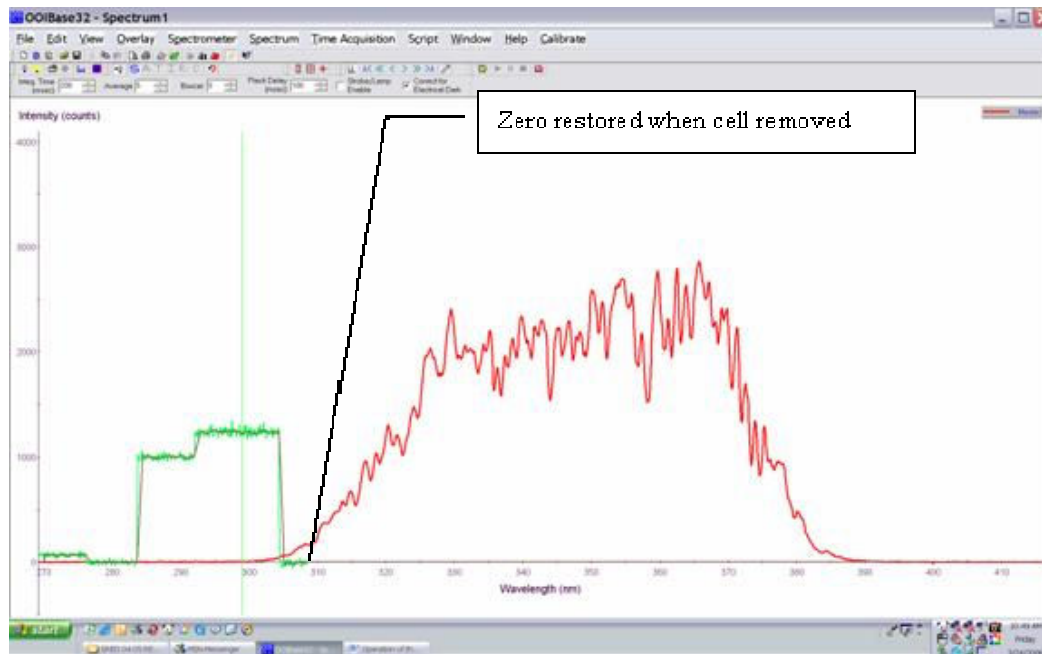
14. Put the high cal cell into the optical path.



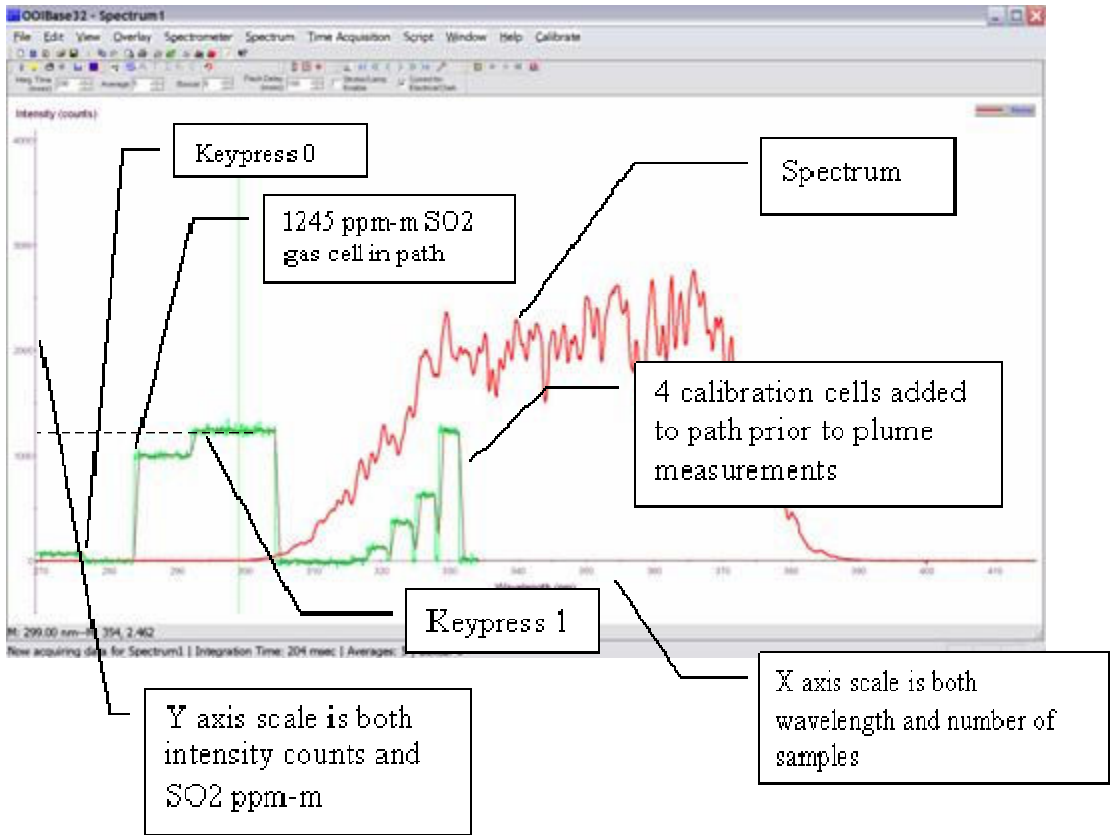
15. Once the average trace is level, hit “1” on the computer keyboard. The trace should level off to the high cal value in 10 seconds.



16. Remove high cell from the optical path. The traces should go to zero. If they do not, press “0” again to re-zero the calibration.



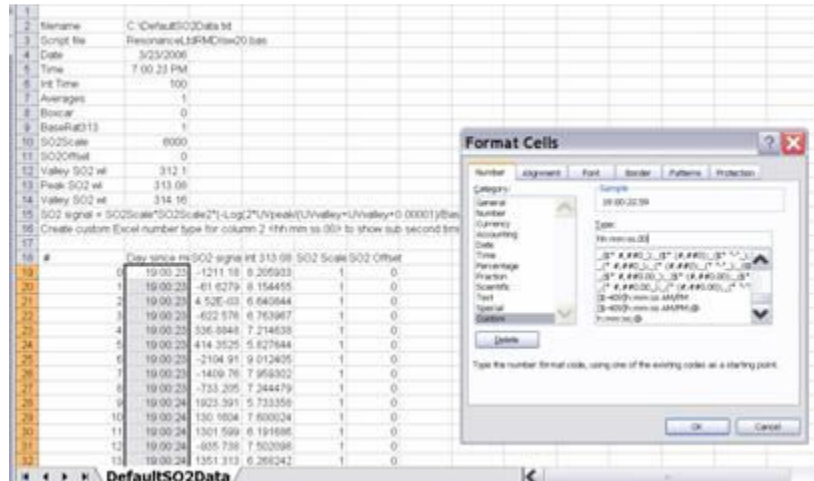
17. This is an ideal time to run through a calibration with all gas cells available:



The illustration above shows the data screen which simultaneously displays the time series of SO₂ in ppm-m and the spectrum of skylight. Both the x and y axes represent two sets of values. The x-axis scale represents wavelength in nm for the spectrum (red) and number of samples for the SO₂ time series (green). The y-axis scale represents the spectrum intensity (counts) and the SO₂ level (ppm-m).

When the macro is running the data is automatically appended to the data text file with the default name DefaultSO₂Data.txt. This file can be directly imported into Excel for creating charts of the data.

To view the data, open this file in Excel. Change the number in the second column using the format cells function to a custom format hh:mm:ss.00. This enables you to have sub second plots of the data using column B as a time axis.



The header stamp with time, date and spectrometer details is put in the file each time the macro is started. The data columns are labeled and as:

Data point number, time with 0.01 second resolution, SO2 signal in ppm-m, 313 sky intensity in counts and the adjusting constants used to correct the readings to the gas cells. These constants can be applied to the data to reverse the calibration in case raw signals are required.

Appendix 1. SPECTROMETER SPECIFICATIONS

Date:

Initial:

Identification:

Spectrometer Model/Serial Number:

Entrance Slit:

Type	Fixed
Height/Width	1 mm/ mm

Exit Detector:

Type	Linear CCD
Pixel	200 x 14 microns
Array Width	28 mm
Spectral coverage	295 to 437 nm
Spectral coverage with UV filter	295 to 385 nm

Grating:

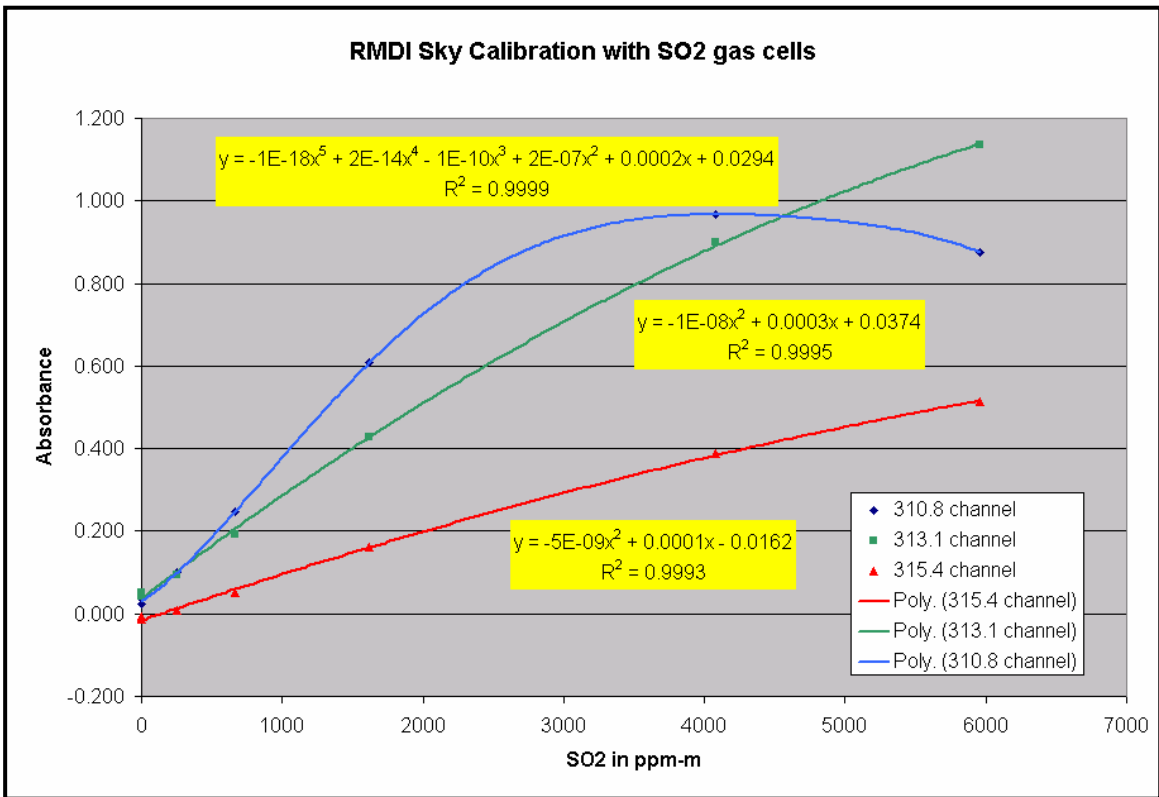
Grooves/mm	2,400/mm
UV type	
Resolution/System	< 0.4 nm first order

Appendix 2: SPECTROMETER CALIBRATION

Date: Initial:

Equipment:

Spectrometer Model/Serial Number RMDI /
Fixed micron slit



Appendix 3: SCRIPT FILE LISTING

```

Attribute VB_Name = "Module1"
'#Reference {00020813-0000-0000-C000-000000000046}#1.3#0#C:\Program
Files\Microsoft Office\Office\EXCEL9.OLB#Microsoft Excel 9.0 Object
Library
'#Reference {00020813-0000-0000-C000-000000000046}#1.4#0#C:\Program
Files\Microsoft Office\Office10\EXCEL.EXE#Microsoft Excel 10.0 Object
Library

'SCRIPT FILE NAME ResonanceLtdRMDIsw21 Mar2006 .bas
'version 2.0
'date Mar. 21, 2006
' The following script processes spectral data for RMDI and RMD-2
'
'=====
'to use on different computer change filename to work on desktop
'the default saves the data on the C drive root directory
'for example on Bill's laptop C:\Documents and Settings\Bill
Morrow\Desktop\SO2...
'will put data on the desktop
'however on another computer the name will be different
'
'To set up for a user one has to put in the value of the high cell sent
to the user in
'the variable HiCalActual
'when this is done one can set the zero by pointing at a clear sky and
hitting number 0 and
'putting in the range and hitting the number 1 key
'This can be repeated to refine the settings.
'This makes the y axis both ppm-m and intensity counts
'=====
' DO NOT MODIFY THE FOLLOWING BLOCK OF CODE
Option Explicit
' #uses "classes\menuverify.bas"
Global ooi As OOIBase32Platinum
Global Ready As Integer
Global Const INITDONE=66
Global InEvent As Boolean
' END NONMODIFYABLE BLOCK
'=====
'=====

Global i As Integer
Global j As Integer
Global jmax As Integer
Global NWL1 As Integer
Global NWL2 As Integer
Global filename As String
Global SWfilename As String
Global ovslot As OVERLAYSLOT
Global PixCount As Integer
'Global wl(3648) As Double

```

```

'Global data(3648) As Double
Global wl(2048) As Double
Global data(2048) As Double
'Global TimeSeries1(3648) As Double
'Global TimeSeries2(3648) As Double
Global TimeSeries1(2048) As Double
Global TimeSeries2(2048) As Double
Global Spect_StWL As Double
Global Spect_EnWL As Double
Global Spect_StWL_2 As Double
Global Spect_EnWL_2 As Double
Global Spect_StWL_3 As Double
Global Spect_EnWL_3 As Double
Global Spect_Stpix As Integer
Global Spect_Enpix As Integer
Global Spect_Stpix_2 As Integer
Global Spect_Enpix_2 As Integer
Global Spect_Stpix_3 As Integer
Global Spect_Enpix_3 As Integer
'Global Spect_Array(3648) As Integer
Global Spect_Array(2048) As Integer
Global chan As SPECCHANNEL
Global WLO As Double      'Wavelength offset parameter
Global WLM As Double      'Wavelength multiplier parameter
Global CWL1(24) As Double  'Center Wavelength array for slit set
(nanometer units)
Global SHW1(24) As Double  'Slit HALF width array for SO2 slit set
(nanometre units)
Global Stpix1(24) As Integer
Global Enpix1(24) As Integer
Global CWL2(15) As Double  'Center Wavelength array for Ozone slit set
(nanometre units)
Global SHW2(15) As Double  'Slit HALF width array for Ozone slit set
(nanometre units)
Global Stpix2(15) As Integer
Global Enpix2(15) As Integer
Global MinWL      As Integer
Global MaxWL      As Integer
Global BaseRat313 As Double
Global BaseRat355 As Double
Global BaseRat369 As Double
Global BaseRat419 As Double
Global BaseRat328 As Double
Global BaseRatO3  As Double
Global BaseRatNO2 As Double
Global StartTimer As Double
Global SO2Scale   As Double
Global SO2Scale2  As Double
Global NO2Scale   As Double
Global SO2Offset  As Double
Global NO2Offset  As Double
Global CalCell11  As Double
Global CalCell12  As Double
Global SigRunAv   As Double
Global SigRunAvTemp As Double

```

```
Global ZeroAv      As Double
Global LowCalAv    As Double
Global MedCalAv    As Double
Global HiCalAv     As Double
Global LowCalActual As Double
Global MedCalActual As Double
Global HiCalActual As Double
```

```
Public Sub EventGenerator_MacroBegin(ByVal modname As String)
'=====
'=====
'      DO NOT MODIFY THE FOLLOWING BLOCK OF CODE
      If Ready=INITDONE Then Exit Sub
      InEvent=False
      Set ooi=New OOIBase32Platinum
'      END NONMODIFYABLE BLOCK
'=====
'=====

      'allocate variables for menus
      Dim SpecMenu As Long
      Dim SpecFileMenu As Long
      Dim NewPopupMenu As Long
      SpecMenu = ooi.Menu.GetSpectrumMenu()
      'print out all the members of menu
          Dim i
          For i=0 To ooi.Menu.GetMenuItemCount(SpecMenu)-1
              '      Debug.Print ooi.Menu.GetMenuString(SpecMenu, i,
mfByPosition)
              Next i
          'get the file submenu
          SpecFileMenu=ooi.Menu.GetSubMenu(SpecMenu,0)
          'add New Data Filename command to the end of the file menu
          ooi.Menu.AppendMenu(SpecFileMenu,mfSeparator,0," ")
          ooi.Menu.AppendMenu(SpecFileMenu,mfString,umFirst,"&New Data
Filename")
          'create a popup menu to add to the main spectrum menu
          NewPopupMenu=ooi.Menu.CreatePopupMenu()
          'add items to the new popup
          ooi.Menu.AppendMenu(NewPopupMenu,mfString,umFirst+1,"&Acquire
Zero")
          ooi.Menu.AppendMenu(NewPopupMenu,mfString,umFirst+2,"&Acquire Cal
cell 1")
          ooi.Menu.AppendMenu(NewPopupMenu,mfString,umFirst+3,"&Acquire Cal
cell 2")
          ooi.Menu.AppendMenu(NewPopupMenu,mfString,umFirst+4,"&Acquire Cal
cell 3")
          'insert new menu into file menu, after help

      ooi.Menu.InsertMenu(SpecMenu,11,mfByPosition+mfPopup,NewPopupMenu,"&Cal
ibrate")
```

```

' get the wavelength array
ooi.SpectralData.GetWavelengths(chan,wl(0))

jmax = 2047
'jmax = 3647
' set starting and ending wavelengths

'Compressed Spectrum Mask

      Spect_StWL = 294.46
      Spect_EnWL= 354.55

'Set spectra save filename to a default
filename = "C:\DefaultSO2Data.txt"

'SO2 MASK

      WLO = 0           'Wave length offset can be used to
correct for temp drift
      WLM = 1           'Wave length span can be used to
correct for temp drift

'for rmdi with start wl at 266.74612 (longest wl is 413.72 NWL1 = 11 to
avoid crash due to out of range wl index

      NWL1 =11          'Number of spectral elements used for
correlation
      CWL1(1) = 298*WLM+WLO 'Center wavelength 1 background
reference
      SHW1(1)      = .25*WLM          'Slit 1 half width corrected
for wave length span

      CWL1(2) = 299*WLM+WLO 'Center wavelength 2 background
reference
      SHW1(2)      = .25*WLM          'Slit 2 half width ....

      CWL1(3) = 312.1*WLM+WLO 'Center wavelength 3 low SO2
absorption
      SHW1(3)      = 0.25*WLM          'Slit 3 half ...

      CWL1(4) = 313.08*WLM+WLO 'Center wavelength 4 high SO2
absorption
      SHW1(4)      = 0.25*WLM          'Slit 4 half width ...

      CWL1(5) = 314.16*WLM+WLO 'Center wavelength 5 low SO2
absorption
      SHW1(5)      = 0.25*WLM          'Slit 5 half width ...

      CWL1(6) = 353.95*WLM+WLO 'Center wavelength 6 Low BrO
absorption
      SHW1(6)      = 0.3*WLM          'Slit 6 half width ...

```

```

absorption      CWL1(7) = 355*WLM+WLO   'Center wavelength 7 high BrO
                SHW1(7)   = 0.3*WLM           'Slit 7 half width ...

absorption      CWL1(8) = 356.04*WLM+WLO   'Center wavelength 8 low BrO
                SHW1(8)   = 0.3*WLM           'Slit 8 half width ...

absorption      CWL1(9) = 367.71*WLM+WLO   'Center wavelength 9 low OC10
                SHW1(9)   = 0.3*WLM           'Slit 9 half width ...

absorption      CWL1(10) = 368.71*WLM+WLO   'Center wavelength 10 hi OC10
                SHW1(10)  = 0.3*WLM           'Slit 9 half width ...

absorption      CWL1(11) = 369.71*WLM+WLO   'Center wavelength 9 low OC10
                SHW1(11)  = 0.3*WLM           'Slit 9 half width ...

pixels from     CWL1(12) = 411.89*WLM+WLO   'Center wavelength 18 low NO2 x
line center     SHW1(12)  = 0.25*WLM           'Slit 18 half width ...

absorption      CWL1(13) = 413.34*WLM+WLO   'Center wavelength 19 hi NO2
slits +1.44 nm - 1.45 SHW1(13) = .25*WLM           'Slit 19 half width ...flanking

absorption      CWL1(14) = 414.78*WLM+WLO   'Center wavelength 20 hi NO2
                SHW1(14)  = .25*WLM           'Slit 20 half width ...

pixels from     CWL1(15) = 326.79*WLM+WLO   'Center wavelength 15 low CS2 9
line center     SHW1(15)  = 0.35*WLM           'Slit 15 half width ...

absorption      CWL1(16) = 327.51*WLM+WLO   'Center wavelength 16 hi CS2
...flanking     SHW1(16)  = .35*WLM           'Slit 16 half width
slits +.72 -.72

absorption      CWL1(17) = 328.23*WLM+WLO   'Center wavelength 17 hi CS2
                SHW1(17)  = .35*WLM           'Slit 17 half width ...

pixels from     CWL1(18) = 411.89*WLM+WLO   'Center wavelength 18 low NO2 x
line center     SHW1(18)  = 0.25*WLM           'Slit 18 half width ...

absorption      CWL1(19) = 413.34*WLM+WLO   'Center wavelength 19 hi NO2

```

```

SHW1(19) = .25*WLM 'Slit 19 half width
...flanking slits +1.44 nm - 1.45

absorption
CWL1(20) = 414.78*WLM+WLO 'Center wavelength 20 hi NO2
SHW1(20) = .25*WLM 'Slit 20 half width ...

pixels from line center
CWL1(21) = 331.8*WLM+WLO 'Center wavelength 21 low O3 x
SHW1(21) = 0.35*WLM 'Slit 21 half width ...

absorption
CWL1(22) = 333.78*WLM+WLO 'Center wavelength 22 hi O3
SHW1(22) = .35*WLM 'Slit 22 half width
...flanking slits +1.98 -1.96

absorption
CWL1(23) = 335.74*WLM+WLO 'Center wavelength 23 hi O3
SHW1(23) = .35*WLM 'Slit 23 half width ...

BaseRat313 = 1.0
BaseRat328 = 1.0
BaseRat355 = 1
BaseRat369 = 1
BaseRat419 = 1
BaseRatO3 = 1
BaseRatNO2 = 1
SO2Scale = 6000
SO2Scale2 = 1
NO2Scale = 25000
SO2Offset = 0
NO2Offset = -1000
SWfilename = "ResonanceLtdRMDIsw20.bas"
ZeroAv =0
LowCalAv =345
MedCalAv =670
HiCalAv =1320
LowCalActual =345
MedCalActual =670
HiCalActual =1245

'put data in overlay slot 1
ooi.Overlay.Active(ovSlot1)=True
ooi.Overlay.Active(ovSlot2)=True

ooi.Overlay.ClearOverlay(ovSlot1)
ooi.Overlay.ClearOverlay(ovSlot2)

j=0

'OZONE MASK: These are the wavelengths and slit widths of a
Brewer Spectrometer mask

NWL2 = 5
CWL2(1) = 306.3*WLM+WLO

```

SHW2(1) = 0.25*WLM 'Slit 1 half width corr for wave
length span

CWL2(2) = 310.0*WLM+WLO
SHW2(2) = 0.25*WLM 'Slit 2 half width...

CWL2(3) = 313.5*WLM+WLO
SHW2(3) = 0.25*WLM 'Slit 3 half width...

CWL2(4) = 316.8*WLM+WLO
SHW2(4) = 0.25*WLM 'Slit 4 half width...

CWL2(5) = 320*WLM+WLO
SHW2(5) = 0.25*WLM 'Slit 5 half width...

' set spectrometer channel
chan=chMaster

' get starting and ending pixel from wavelengths

```
'For compressed spectrum
    Spect_Stpix =
ooi.Spectrometer.wavelength.GetPixel(chan,Spect_StWL)
    Spect_Enpix =
ooi.Spectrometer.wavelength.GetPixel(chan,Spect_EnWL)
'For SO2 mask
    For i = 1 To NWL1
        Stpix1(i)
=ooi.Spectrometer.wavelength.GetPixel(chan,CWL1(i)-SHW1(1))
        Enpix1(i)
=ooi.Spectrometer.wavelength.GetPixel(chan,CWL1(i)+SHW1(1))
    Next i
```

```
'=====
'=====
```

```
' DO NOT MODIFY THE FOLLOWING BLOCK OF CODE
Ready=INITDONE
' END NONMODIFYABLE BLOCK
```

```
'=====
'=====
```

End Sub

Public Sub EventGenerator_NewSpectraReady(ByVal windowname As String,
ByVal channels As Integer)

```
'=====
'=====
```

```
' DO NOT MODIFY THE FOLLOWING BLOCK OF CODE
If Ready<>INITDONE Then Exit Sub
If ooi.InNextScanWait=True Then
    ooi.InNextScanWait=False
Exit Sub
End If
If ooi.InTimeWait=True Then Exit Sub
```

```

If InEvent=True Then Exit Sub
InEvent=True
'
'           END NONMODIFYABLE BLOCK
'=====
'=====

' define local variables
  Dim M As Double
  Dim X As Double
  Dim B As Double
  Dim RFlux1(24)
  Dim CRFlux1(24)
  Dim CRFlux2(5)
  Dim RFlux2(5)
  Dim CurPix As Integer

'Update Time Tic
' get processed spectral data
ooi.SpectralData.GetProcessedSpectrum(chMaster,data(0))

'***** Create compressed spectrum *****
'Create average
' integrate
For i =1 To NWL1
  RFlux1(i) = 0
  For CurPix = Stpix1(i) To Enpix1(i)
    RFlux1(i) = RFlux1(i) + data(CurPix)
  Next CurPix
  RFlux1(i) = RFlux1(i)/(Enpix1(i)-Stpix1(i))
Next i

For i =1 To NWL2
  RFlux2(i) = 0
  For CurPix = Stpix2(i) To Enpix2(i)
    RFlux2(i) = RFlux2(i) + data(CurPix)
  Next CurPix
  RFlux2(i) = RFlux2(i)/(Enpix2(i)-Stpix2(i))
Next i

M = (RFlux1(2)-RFlux1(1))/(CWL1(2)-CWL1(1))
B = 0      'RFlux1(1)      remove reference to reduce noise

For i = 1 To 2
  CRFlux1(i) = RFlux1(i)
Next i

For i = 3 To NWL1
  CRFlux1(i) = RFlux1(i) - B
Next i

' USE CODE BELOW To put Data into chart and save file

```

```

TimeSeries1(j) = SO2Scale2*SO2Scale*(-
Log(2*CRFlux1(4)/(CRFlux1(3)+CRFlux1(5)+0.00001)/BaseRat313)) +
SO2Offset

Dim i

If j>10 Then
    SigRunAvTemp = 0
    For i = 0 To 9
        SigRunAvTemp = SigRunAvTemp +TimeSeries1(j-i)
    Next i
    SigRunAv = SigRunAvTemp/10
End If

TimeSeries2(j) = SigRunAv
'append timeseries1(j) and timeseries2(j) to file

Open filename For Append As #1

If j= 0 Then
    Print #1,
    Print #1, "filename"& Chr$(9) & filename & "
    Print #1, "Script file"& Chr$(9) & SWfilename & "
    Print #1, "Date      "& Chr$(9) & Date & "
    Print #1, "Time      "& Chr$(9) & Time & "
    Print #1, "Int Time"& Chr$(9) &
ooi.AcquisitionParameters.IntegrationTime
    Print #1, "Averages"& Chr$(9) &
ooi.AcquisitionParameters.Averages
    Print #1, "Boxcar  "& Chr$(9) &
ooi.AcquisitionParameters.Boxcar

    Print #1, "BaseRat313"& Chr$(9) & BaseRat313

    Print #1, "SO2Scale "      & Chr$(9) & SO2Scale
    Print #1, "SO2Offset "  & Chr$(9) & SO2Offset
    Print #1, "Valley SO2 wl" & Chr$(9) & CWL1(3)
    Print #1, "Peak SO2 wl " & Chr$(9) & CWL1(4)
    Print #1, "Valley SO2 wl" & Chr$(9) & CWL1(5)
    Print #1, "SO2 signal = SO2Scale*SO2Scale2*(-
Log(2*UVpeak/(UVvalley+UVvalley+0.00001)/BaseRat313)) +
SO2Scale2*SO2Offset"
    Print #1, "Create custom Excel number type for column 2
<hh:mm:ss.00> to show sub second timing"
    Print #1
    Print #1, " # " &Chr$(9)& "Day since midnite"
&Chr$(9)& "SO2 signal      " &Chr$(9)& "Int 313.08 nm" &Chr$(9)&
"SO2 Scale2" &Chr$(9)& "SO2 Offset"

End If

'tab separated data tab is ascii character 9

```

```
Print #1, "" & j & Chr$(9) & Timer/24/3600 & Chr$(9) &
TimeSeries1(j) & Chr$(9) & CRFlux1(4) & Chr$(9) & SO2Scale2 & Chr$(9)
& SO2Offset
```

```
Close #1
```

```
Debug.Print (TimeSeries1(j))
```

```
ooi.Overlay.ClearOverlay(ovSlot1)
ooi.Overlay.ClearOverlay(ovSlot2)
```

```
ooi.Overlay.SetOverlayWavelength(ovSlot1, wl(0))
ooi.Overlay.SetOverlayIntensity(ovSlot1, TimeSeries1(0))
ooi.Overlay.SetOverlayWavelength(ovSlot2, wl(0))
```

```
'Averaged signal
```

```
ooi.Overlay.SetOverlayIntensity(ovSlot2, TimeSeries2(0))
```

```
j = j+1
```

```
If j > jmax-1 Then
```

```
ooi.Overlay.ClearOverlay(ovSlot1)
ooi.Overlay.ClearOverlay(ovSlot2)
```

```
For j=0 To 2047
    TimeSeries1(j) = 0
    TimeSeries2(j) = 0
Next j
```

```
Next j
```

```
j=0
```

```
End If
```

```
'=====
'=====
' DO NOT MODIFY THE FOLLOWING BLOCK OF CODE
' InEvent=False
' END NONMODIFYABLE BLOCK
'=====
'=====
```

```
End Sub
```

```
Public Sub EventGenerator_UserMenu(ByVal menuid As Long)
```

```
    Select Case menuid
```

```
        Case umFirst
```

```
            ' Enter a file name to save the SO2 and NO2 data
```

```
            filename = InputBox("Enter File Name For Saving Data
```

```
Using The Form Directory\FileName.txt" , filename, "C:\Data.txt",,)
```

```
            Debug.Print filename
```

```
        Case umFirst+1
```

```
            ' Acquire zero by pointing RMDI away from plume
```

```
            ZeroAv = SigRunAv
```

```
            Debug.Print " zero calibration value" & " " & ZeroAv
```

```
    End Select
```

End Sub

```
Public Sub EventGenerator_Keystroke(ByVal keycode As Long, ByVal flags
As Long, ByVal windowname As String)
```

```
    If Str(keycode) = 48 Then
        ' Acquire reference by pointing RMDI away from plume
        SO2Offset = -SigRunAv+SO2Offset
        Debug.Print " zero calibration value" & " " &
SO2Offset

        ElseIf Str(keycode) = 49 Then
            ' Acquire high cal inserting high cell and with
RMDI away from plume
            HiCalAv = SigRunAv
            SO2Scale2 = HiCalActual/HiCalAv*SO2Scale2
            SO2Offset = SO2Offset*SO2Scale2
            Debug.Print " high cell calibration value" & "
" & SO2Scale2 & " " & HiCalAv
            Else

                End If
```

End Sub

```
Public Sub Errorreport()
```

End Sub

```
Public Sub EventGenerator_MacroEnd()
    ' when the macro exists, restore the default spectrum menu adn
clear overlays
    ooi.Menu.ReloadDefaultSpectrumMenu()
    ooi.Overlay.ClearOverlay(ovSlot1)
    ooi.Overlay.ClearOverlay(ovSlot2)
    ooi.Overlay.ClearOverlay(ovSlot3)
    ooi.Overlay.ClearOverlay(ovSlot4)
    ooi.Overlay.ClearOverlay(ovSlot5)
    ooi.Overlay.ClearOverlay(ovSlot6)
    ooi.Overlay.ClearOverlay(ovSlot7)
    ooi.Overlay.ClearOverlay(ovSlot8)
    ooi.Menu.RedrawAllSpectrumMenus()
```

End Sub

Appendix 4: EXAMPLE DATA FILE

filename C:\Documents and Settings\Administrator\Desktop\DefaultSO2Data.txt

Script file ResonanceLtdRMDIsw20.bas

Date 12/16/2005

Int Time 1000

Averages 1

Boxcar 0

BaseRat313 1

SO2Scale 6000

SO2Offset 0

Valley SO2 wl 312.1

Peak SO2 wl 313.08

Valley SO2 wl 314.16

SO2 signal = SO2Scale*(-Log(2*UVpeak/(UVvalley+UVvalley+0.00001)/BaseRat313)) + SO2Offset

Create custom Excel number type for column 2 <hh:mm:ss.00> to show sub second timing

#	Day since midnite	SO2 signal	Int 313.08 nm
0	0.39200023509838	186.990793078869	953.333333333333
1	0.392012080439815	231.479905471265	952.166666666667
2	0.392023880570023	255.782722897831	952.333333333333
3	0.392035725911458	208.27392983724	955.5
4	0.392047661675347	226.475216762721	955.666666666667
5	0.392059461805556	251.083913031656	957.166666666667
6	0.392071307146991	234.170380655137	957.166666666667
7	0.392083107277199	181.771259684327	963.333333333333
8	0.392095043041088	216.976520895107	965
9	0.392106888382523	187.674193570121	968.166666666667
10	0.392118688512731	289.185471789466	958.833333333333
11	0.392130533854167	214.23691767031	962.5
12	0.392142333984375	239.665461239804	962.833333333333
13	0.392154269748264	214.337114143955	964.333333333333
14	0.392166115089699	246.545155580532	959.833333333333
15	0.392177915219907	247.019621920148	963.333333333333
16	0.392189760561343	233.373313636719	960.5
17	0.392201696325231	249.984508598134	958.666666666667
18	0.39221349645544	213.246462248931	958.166666666667
19	0.392225341796875	222.372312593151	958.5
20	0.392237141927083	179.382760957104	967.333333333333
21	0.392249077690972	304.39456327988	951.166666666667
22	0.392260923032407	242.266589068422	960.666666666667
23	0.392272723162616	286.850002022535	849.166666666667
24	0.392284568504051	842.232667802835	547.833333333333
25	0.392296368634259	908.583021851191	542.166666666667
26	0.392308304398148	938.975666330216	540.333333333333
27	0.392320149739583	891.745805016442	542.5
28	0.392331949869792	952.466406547435	546.666666666667
29	0.392343795211227	926.516067058531	544.333333333333
30	0.392355730975116	881.093076927447	544.666666666667
31	0.392367531105324	941.383022873723	544.166666666667
32	0.392379376446759	888.176935641735	545.666666666667
33	0.392391176576968	912.008749926688	548.166666666667
34	0.392403157552083	892.471614769026	547.666666666667
35	0.392414957682292	875.050084416549	550
36	0.392426803023727	904.666510729982	548.5
37	0.392438603153935	934.893932788075	545
38	0.39245044849537	925.689004071144	546