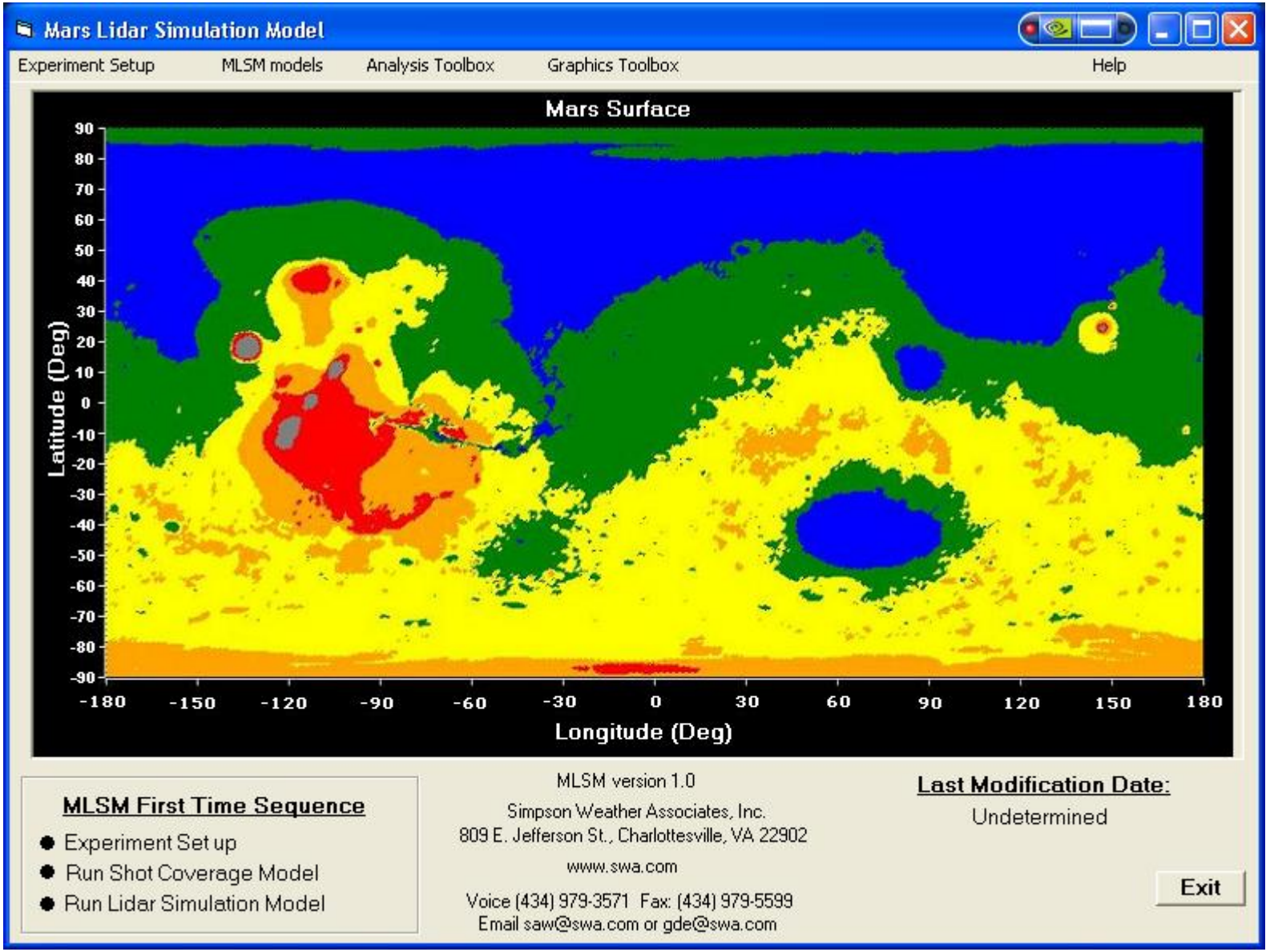
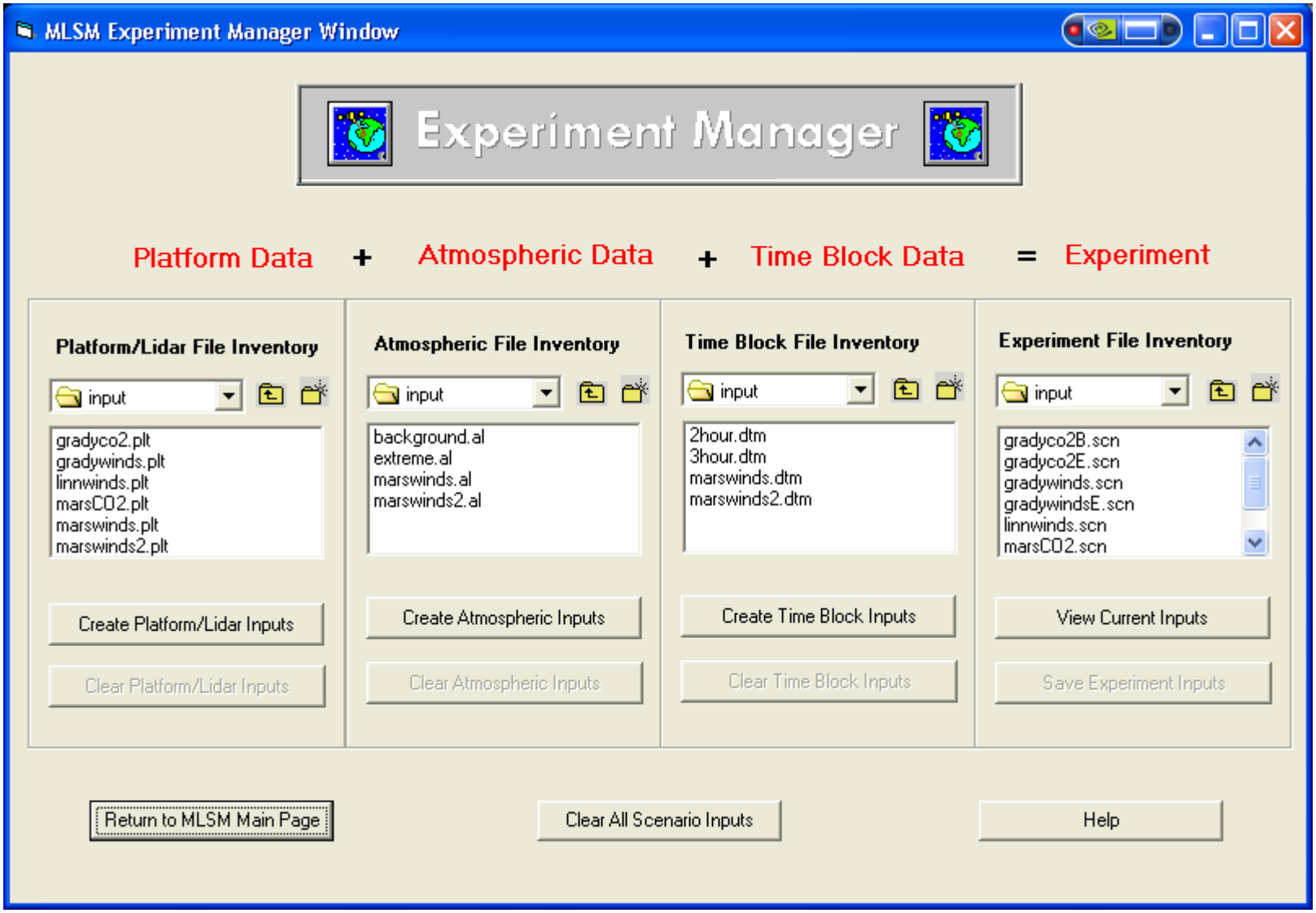
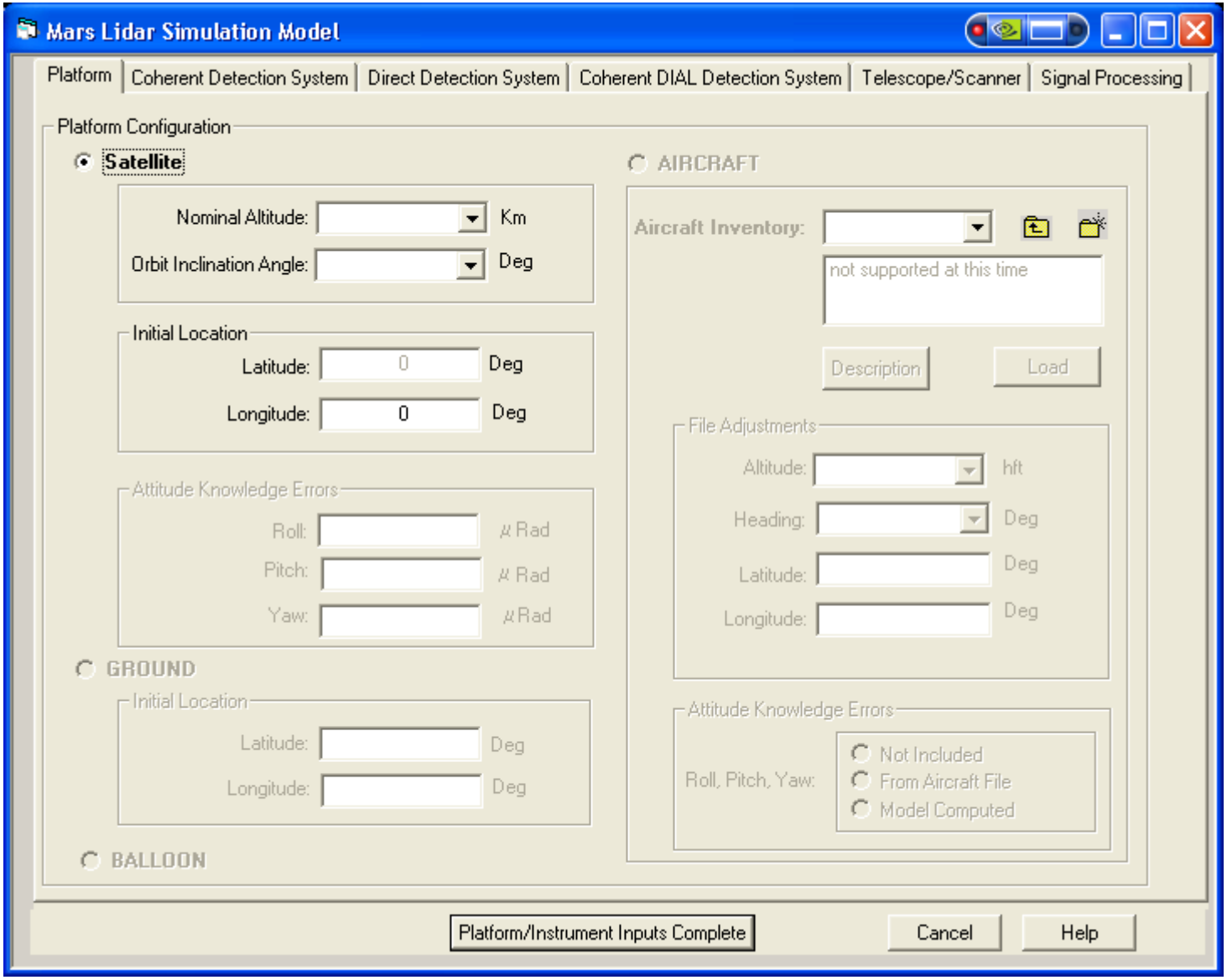
MLSM

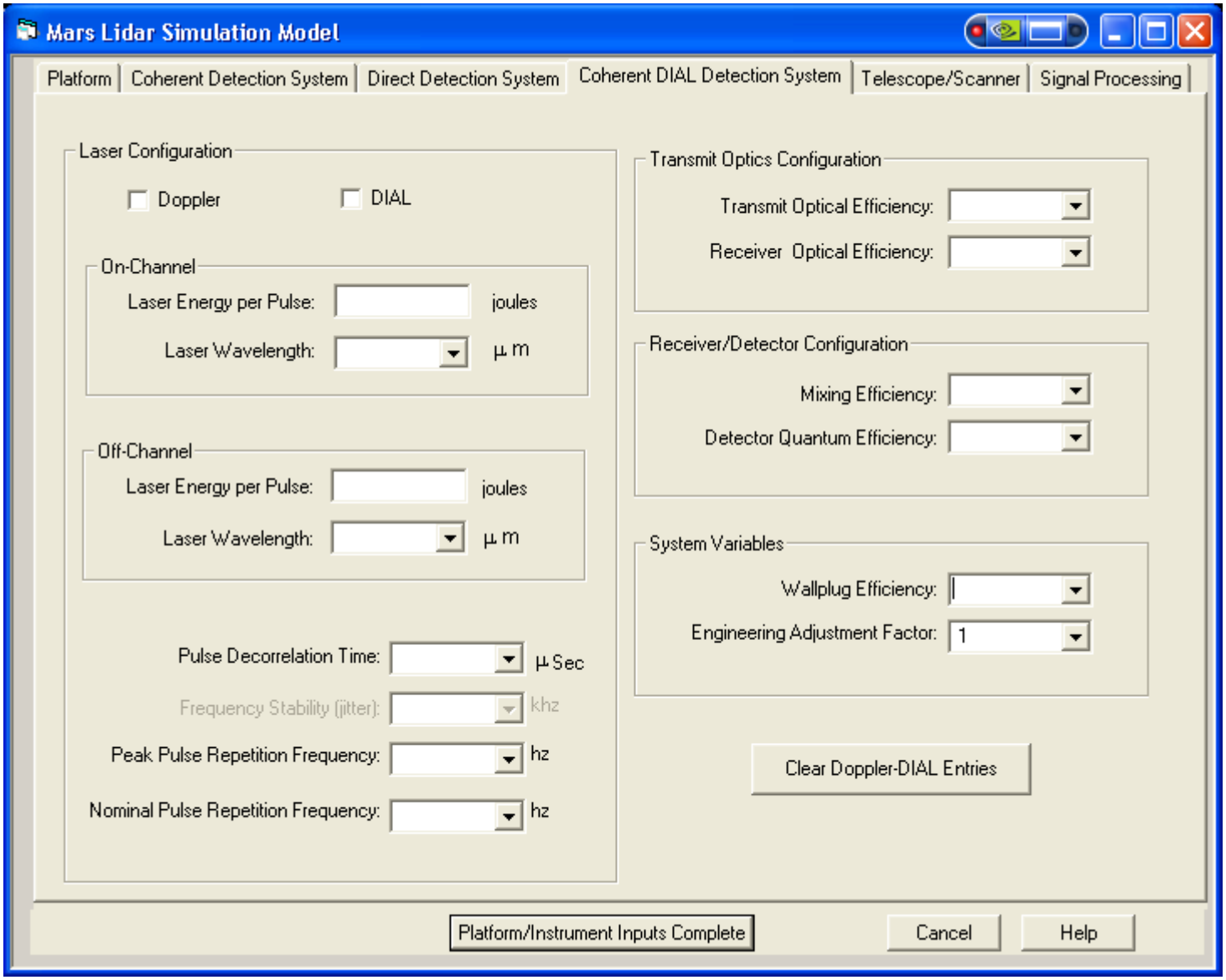
Mars Lidar Simulation Model

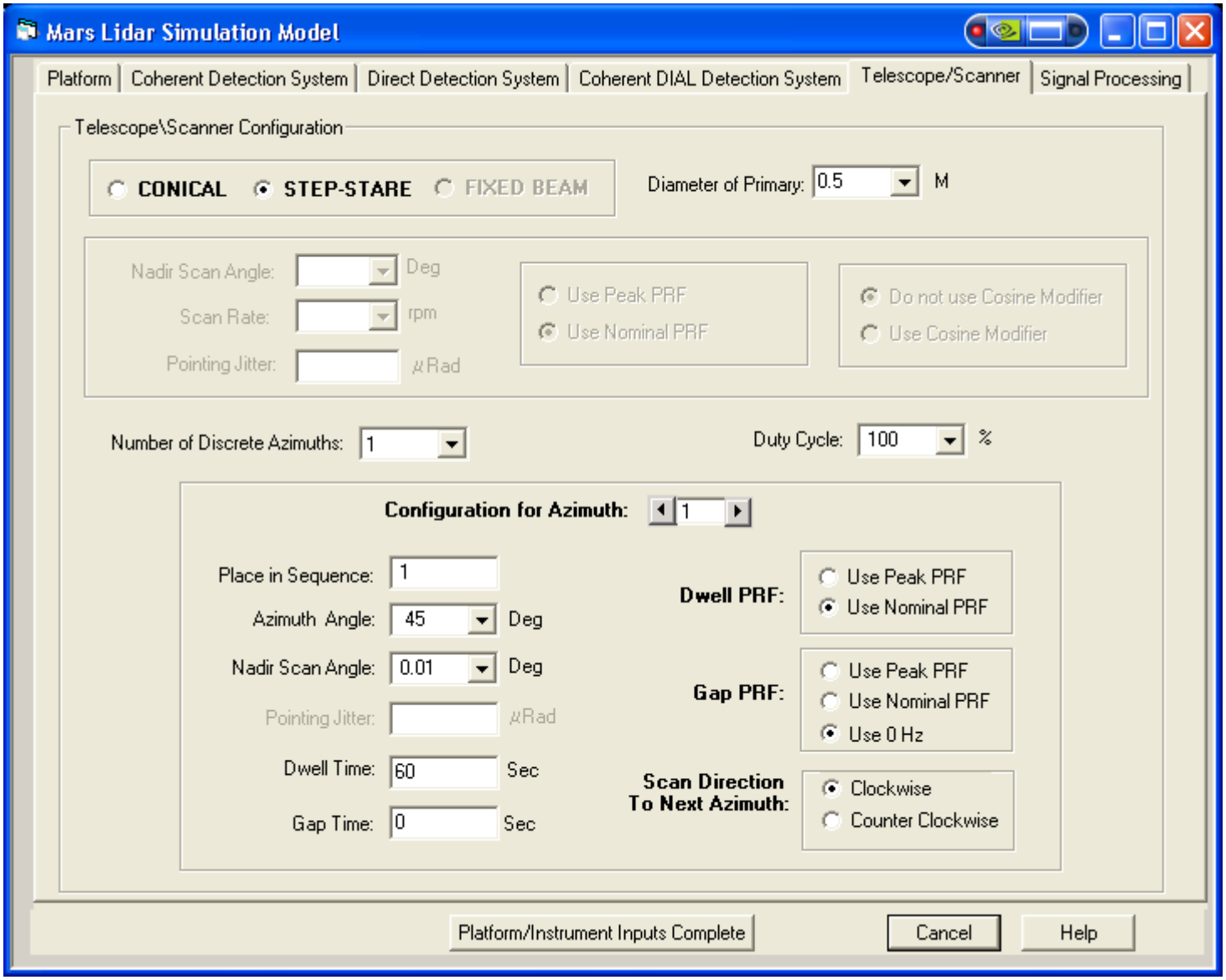
Simpson Weather Associates, Inc.

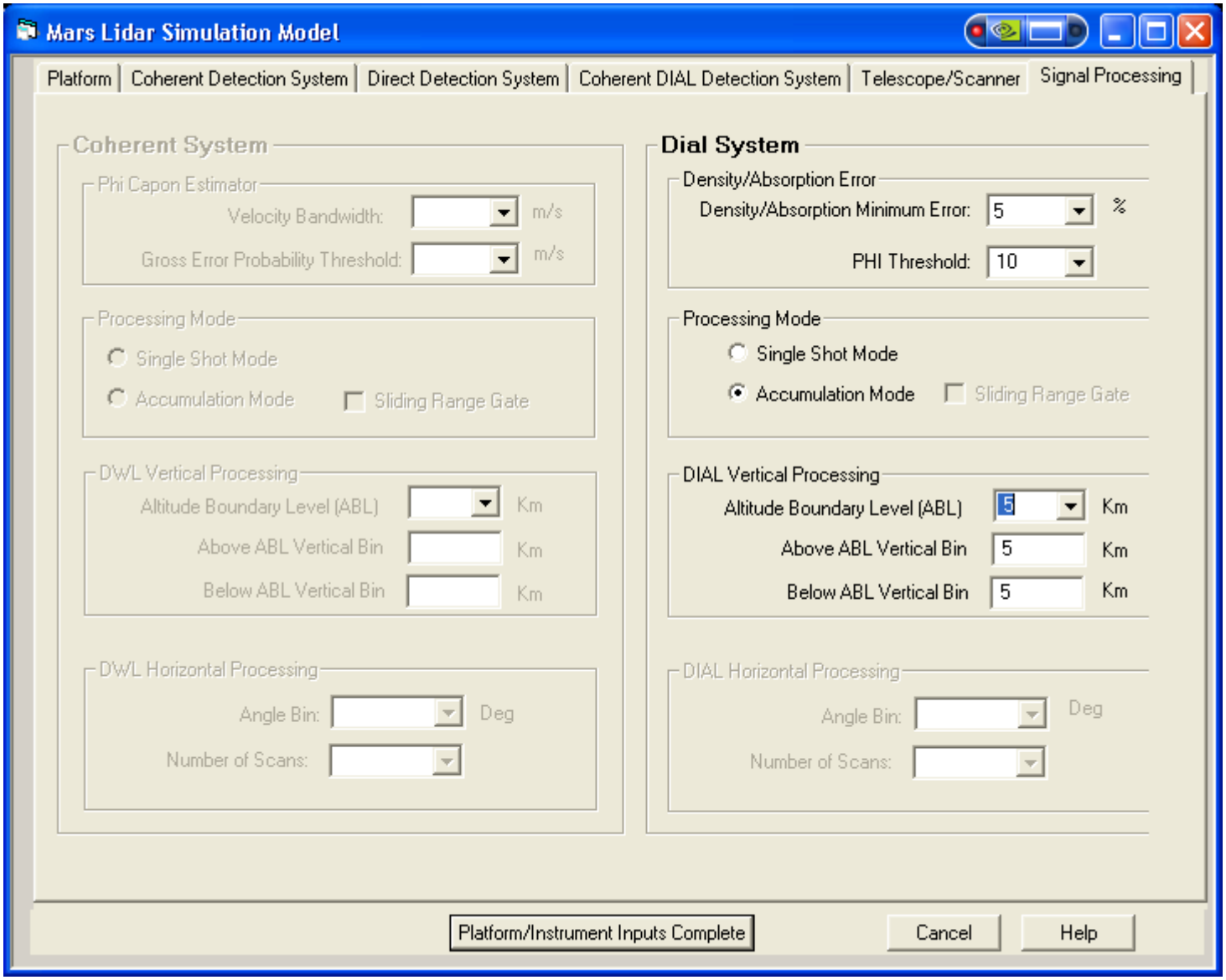

Mars Lidar Simulation Model
Experiment Setup
MLSM models
Analysis Toolbox
Graphics Toolbox
Help
Mars Surface
Latitude (Deg)
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-180
-150
-120
-90
-60
-30
0
30
60
90
120
150
180
Longitude (Deg)
MLSM First Time Sequence
Experiment Set up
Run Shot Coverage Model
Run Lidar Simulation Model
MLSM version 1.0
Simpson Weather Associates, Inc.
809 E. Jefferson St., Charlottesville, VA 22902
www.swa.com
Voice (434) 979-3571 Fax: (434) 979-5599
Email saw@swa.com or gde@swa.com
Last Modification Date:
Undetermined
Exit

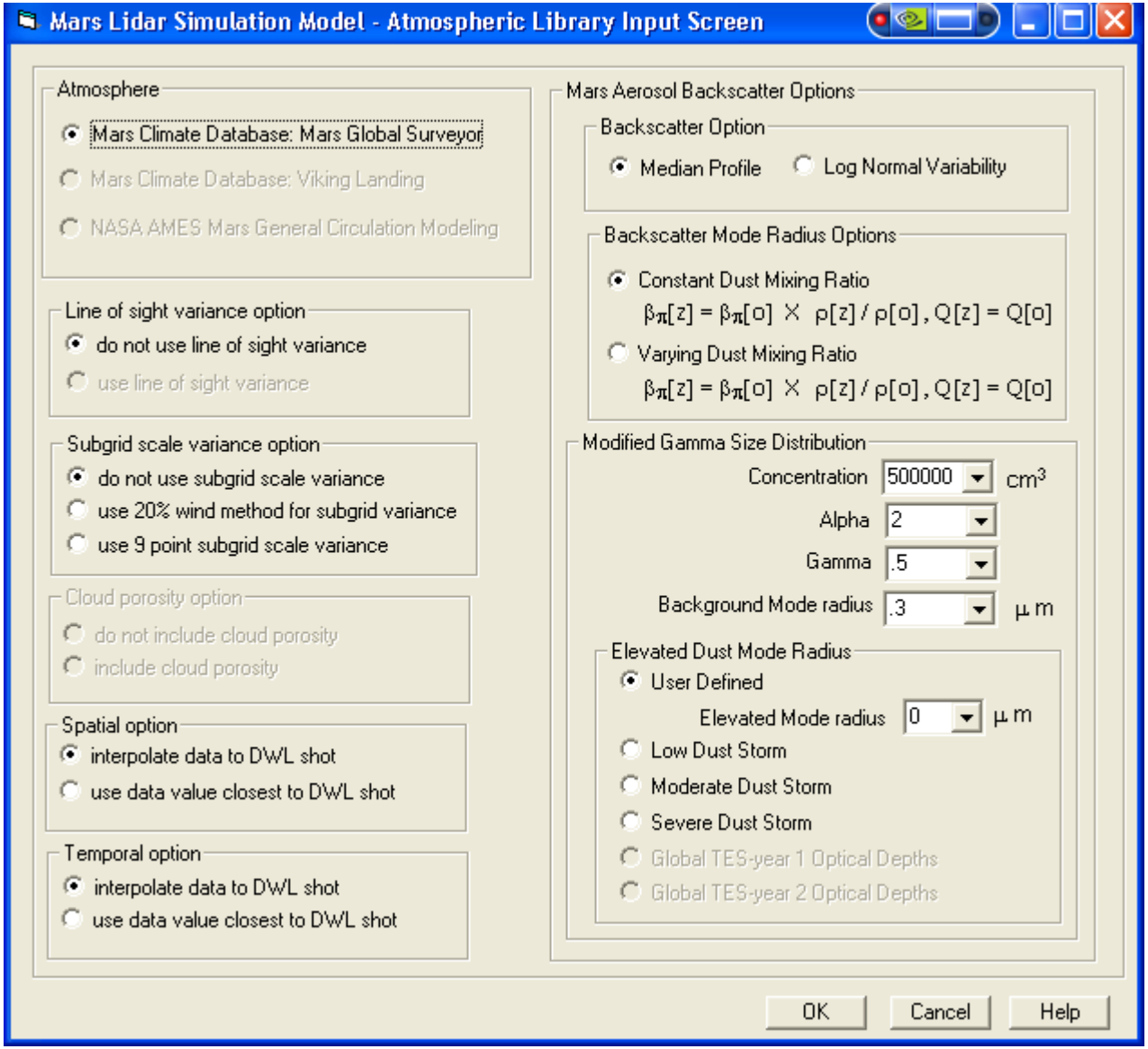

MLSM Experiment Manager Window
Experiment Manager
Platform Data + Atmospheric Data + Time Block Data = Experiment
Platform/Lidar File Inventory
input
gradyco2.plt
gradywinds.plt
linnwinds.plt
marsCO2.plt
marswinds.plt
marswinds2.plt
Create Platform/Lidar Inputs
Clear Platform/Lidar Inputs
Atmospheric File Inventory
input
background.al
extreme.al
marswinds.al
marswinds2.al
Create Atmospheric Inputs
Clear Atmospheric Inputs
Time Block File Inventory
input
2hour.dtm
3hour.dtm
marswinds.dtm
marswinds2.dtm
Create Time Block Inputs
Clear Time Block Inputs
Experiment File Inventory
input
gradyco2B.scn
gradyco2E.scn
gradywinds.scn
gradywindsE.scn
linnwinds.scn
marsCO2.scn
View Current Inputs
Save Experiment Inputs
Return to MLSM Main Page
Clear All Scenario Inputs
Help

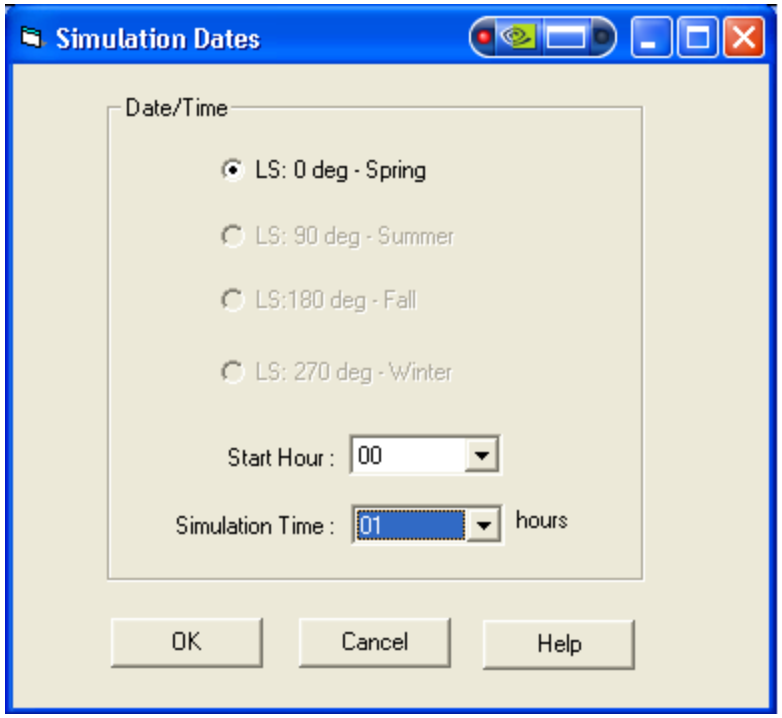

Mars Lidar Simulation Model
Platform
Coherent Detection System
Direct Detection System
Coherent DIAL Detection System
Telescope/Scanner
Signal Processing
Platform Configuration
Satellite
Nominal Altitude:
Km
Orbit Inclination Angle:
Deg
Initial Location
Latitude:
0
Deg
Longitude:
0
Deg
Attitude Knowledge Errors
Roll:
μ Rad
Pitch:
μ Rad
Yaw:
μ Rad
GROUND
Initial Location
Latitude:
Deg
Longitude:
Deg
BALLOON
AIRCRAFT
Aircraft Inventory:
not supported at this time
Description
Load
File Adjustments
Altitude:
hft
Heading:
Deg
Latitude:
Deg
Longitude:
Deg
Attitude Knowledge Errors
Roll, Pitch, Yaw:
Not Included
From Aircraft File
Model Computed
Platform/Instrument Inputs Complete
Cancel
Help

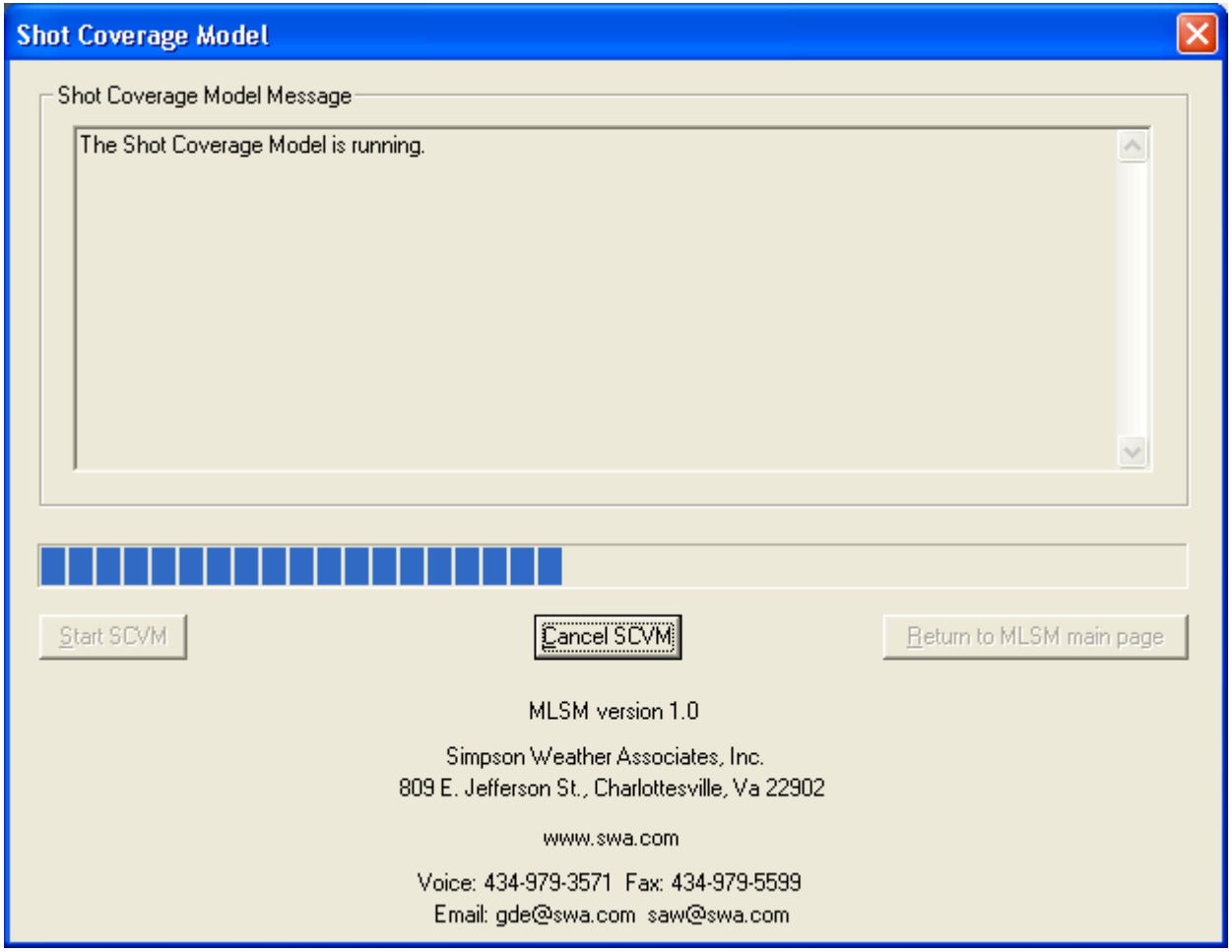

Mars Lidar Simulation Model
Platform
Coherent Detection System
Direct Detection System
Coherent DIAL Detection System
Telescope/Scanner
Signal Processing
Laser Configuration
Doppler
DIAL
On-Channel
Laser Energy per Pulse:
joules
Laser Wavelength:
μ m
Off-Channel
Laser Energy per Pulse:
joules
Laser Wavelength:
μ m
Pulse Decorrelation Time:
μ Sec
Frequency Stability (jitter):
khz
Peak Pulse Repetition Frequency:
hz
Nominal Pulse Repetition Frequency:
hz
Transmit Optics Configuration
Transmit Optical Efficiency:
Receiver Optical Efficiency:
Receiver/Detector Configuration
Mixing Efficiency:
Detector Quantum Efficiency:
System Variables
Wallplug Efficiency:
Engineering Adjustment Factor:
1
Clear Doppler-DIAL Entries
Platform/Instrument Inputs Complete
Cancel
Help


Mars Lidar Simulation Model
Platform
Coherent Detection System
Direct Detection System
Coherent DIAL Detection System
Telescope/Scanner
Signal Processing
Telescope\Scanner Configuration
CONICAL
STEP-STARE
FIXED BEAM
Diameter of Primary:
0.5
M
Nadir Scan Angle:
Deg
Scan Rate:
rpm
Pointing Jitter:
µRad
Use Peak PRF
Use Nominal PRF
Do not use Cosine Modifier
Use Cosine Modifier
Number of Discrete Azimuths:
1
Duty Cycle:
100
%
Configuration for Azimuth:
1
Place in Sequence:
1
Azimuth Angle:
45
Deg
Nadir Scan Angle:
0.01
Deg
Pointing Jitter:
µRad
Dwell Time:
60
Sec
Gap Time:
0
Sec
Dwell PRF:
Use Peak PRF
Use Nominal PRF
Gap PRF:
Use Peak PRF
Use Nominal PRF
Use 0 Hz
Scan Direction To Next Azimuth:
Clockwise
Counter Clockwise
Platform/Instrument Inputs Complete
Cancel
Help


Mars Lidar Simulation Model
Platform
Coherent Detection System
Direct Detection System
Coherent DIAL Detection System
Telescope/Scanner
Signal Processing
Coherent System
Phi Capon Estimator
Velocity Bandwidth:
m/s
Gross Error Probability Threshold:
m/s
Processing Mode
Single Shot Mode
Accumulation Mode
Sliding Range Gate
DWL Vertical Processing
Altitude Boundary Level (ABL)
Km
Above ABL Vertical Bin
Km
Below ABL Vertical Bin
Km
DWL Horizontal Processing
Angle Bin:
Deg
Number of Scans:
Dial System
Density/Absorption Error
Density/Absorption Minimum Error:
5
%
PHI Threshold:
10
Processing Mode
Single Shot Mode
Accumulation Mode
Sliding Range Gate
DIAL Vertical Processing
Altitude Boundary Level (ABL)
5
Km
Above ABL Vertical Bin
5
Km
Below ABL Vertical Bin
5
Km
DIAL Horizontal Processing
Angle Bin:
Deg
Number of Scans:
Platform/Instrument Inputs Complete
Cancel
Help


Mars Lidar Simulation Model - Atmospheric Library Input Screen
Atmosphere
Mars Climate Database: Mars Global Surveyor
Mars Climate Database: Viking Landing
NASA AMES Mars General Circulation Modeling
Line of sight variance option
do not use line of sight variance
use line of sight variance
Subgrid scale variance option
do not use subgrid scale variance
use 20% wind method for subgrid variance
use 9 point subgrid scale variance
Cloud porosity option
do not include cloud porosity
include cloud porosity
Spatial option
interpolate data to DWL shot
use data value closest to DWL shot
Temporal option
interpolate data to DWL shot
use data value closest to DWL shot
Mars Aerosol Backscatter Options
Backscatter Option
Median Profile
Log Normal Variability
Backscatter Mode Radius Options
Constant Dust Mixing Ratio
βπ[z] = βπ[o] × ρ[z] / ρ[o], Q[z] = Q[o]
Varying Dust Mixing Ratio
βπ[z] = βπ[o] × ρ[z] / ρ[o], Q[z] = Q[o]
Modified Gamma Size Distribution
Concentration 500000 cm3
Alpha 2
Gamma .5
Background Mode radius .3 μm
Elevated Dust Mode Radius
User Defined
Elevated Mode radius 0 μm
Low Dust Storm
Moderate Dust Storm
Severe Dust Storm
Global TES-year 1 Optical Depths
Global TES-year 2 Optical Depths
OK
Cancel
Help


Simulation Dates
Date/Time
LS: 0 deg - Spring
LS: 90 deg - Summer
LS:180 deg - Fall
LS: 270 deg - Winter
Start Hour :
00
Simulation Time :
01
hours
OK
Cancel
Help


Shot Coverage Model
Shot Coverage Model Message
The Shot Coverage Model is running.
Start SCVM
Cancel SCVM
Return to MLSM main page
MLSM version 1.0
Simpson Weather Associates, Inc.
809 E. Jefferson St., Charlottesville, Va 22902
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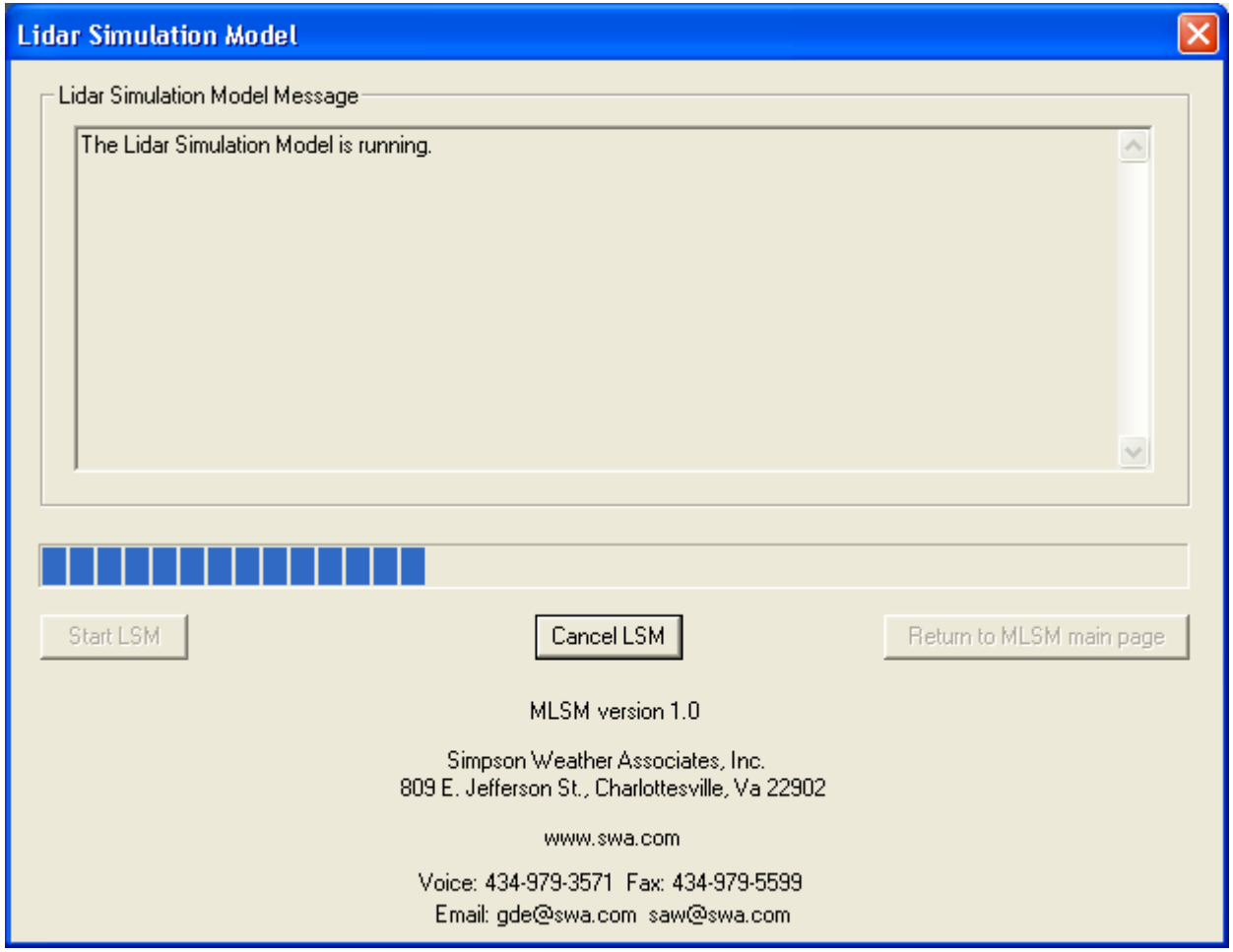
Email: gde@swa.com saw@swa.com


Lidar Simulation Model
Lidar Simulation Model Message
The Lidar Simulation Model is running.
Start LSM
Cancel LSM
Return to MLSM main page
MLSM version 1.0
Simpson Weather Associates, Inc.
809 E. Jefferson St., Charlottesville, Va 22902
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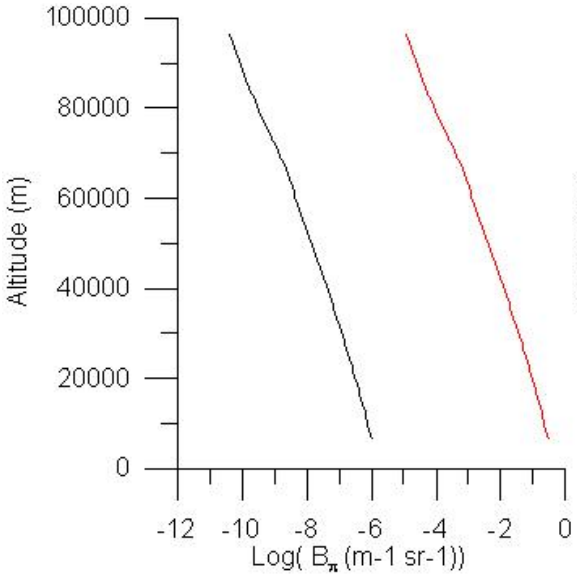
Email: gde@swa.com saw@swa.com

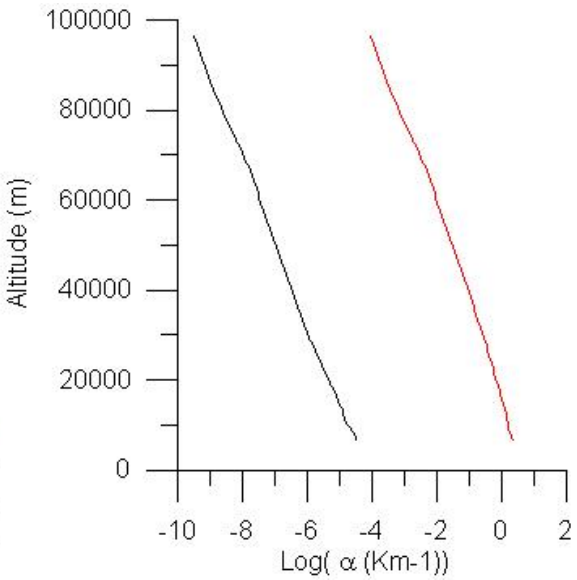
MLSM

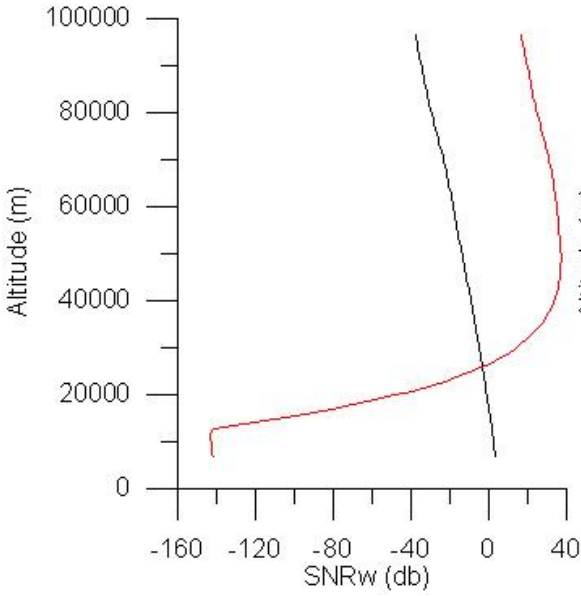
Mars DWL Simulation

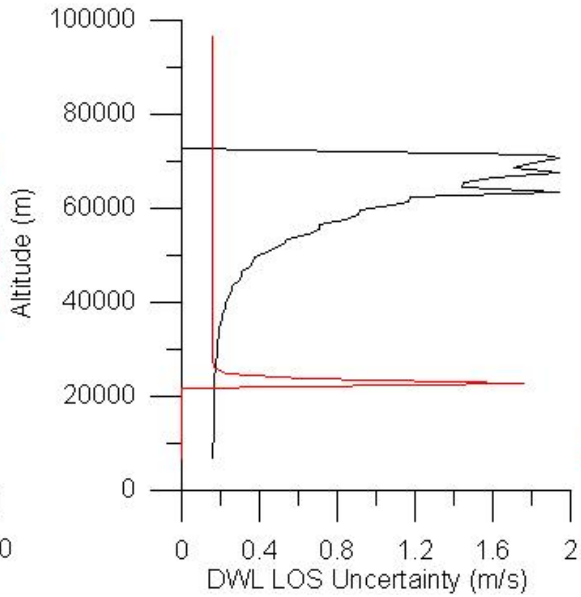
Simpson Weather Associates, Inc.

DWL Single Profile Bracketing Performances









Background Dust
Extreme Dust

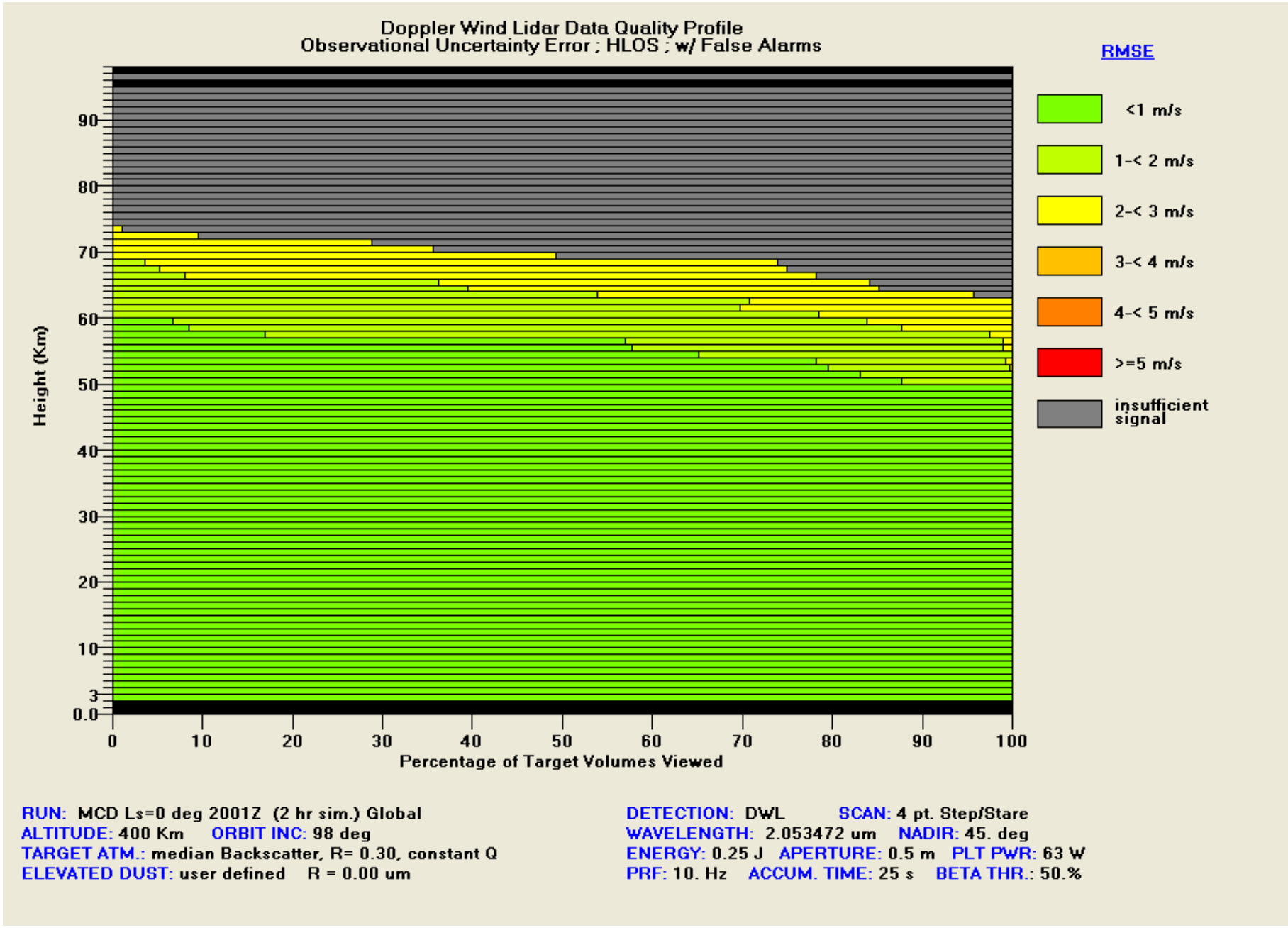
PLATFORM INPUTS
Starting altitude of the satellite (km): 400.00
Starting orbit inclination angle (deg): 98.00

LASER SYSTEM INPUTS
Energy per pulse (joules) for DWL lidar: 0.25
Laser wavelength (um) for DWL lidar: 2.053472
Pulse duration (u-sec): 2.00
Prf of the scanner (hz): 10.00

TELESCOPE/SCANNER INPUTS
Scanner shot manager type: step/stare
Diameter of the primary telescope mirror (m): 0.50
Number of discrete azimuths: 4
Nadir scan angle for each azim. ang. (deg): 45.00
Time for a fix/SS beam to fire shots (s): 25.00
Fixed/step-stare discrete azim. ang. (deg): 45.00
Fixed/step-stare discrete azim. ang. (deg): 135.00
Fixed/step-stare discrete azim. ang. (deg): 225.00
Fixed/step-stare discrete azim. ang. (deg): 315.00
Duty cycle of the scan pattern (%): 100.00

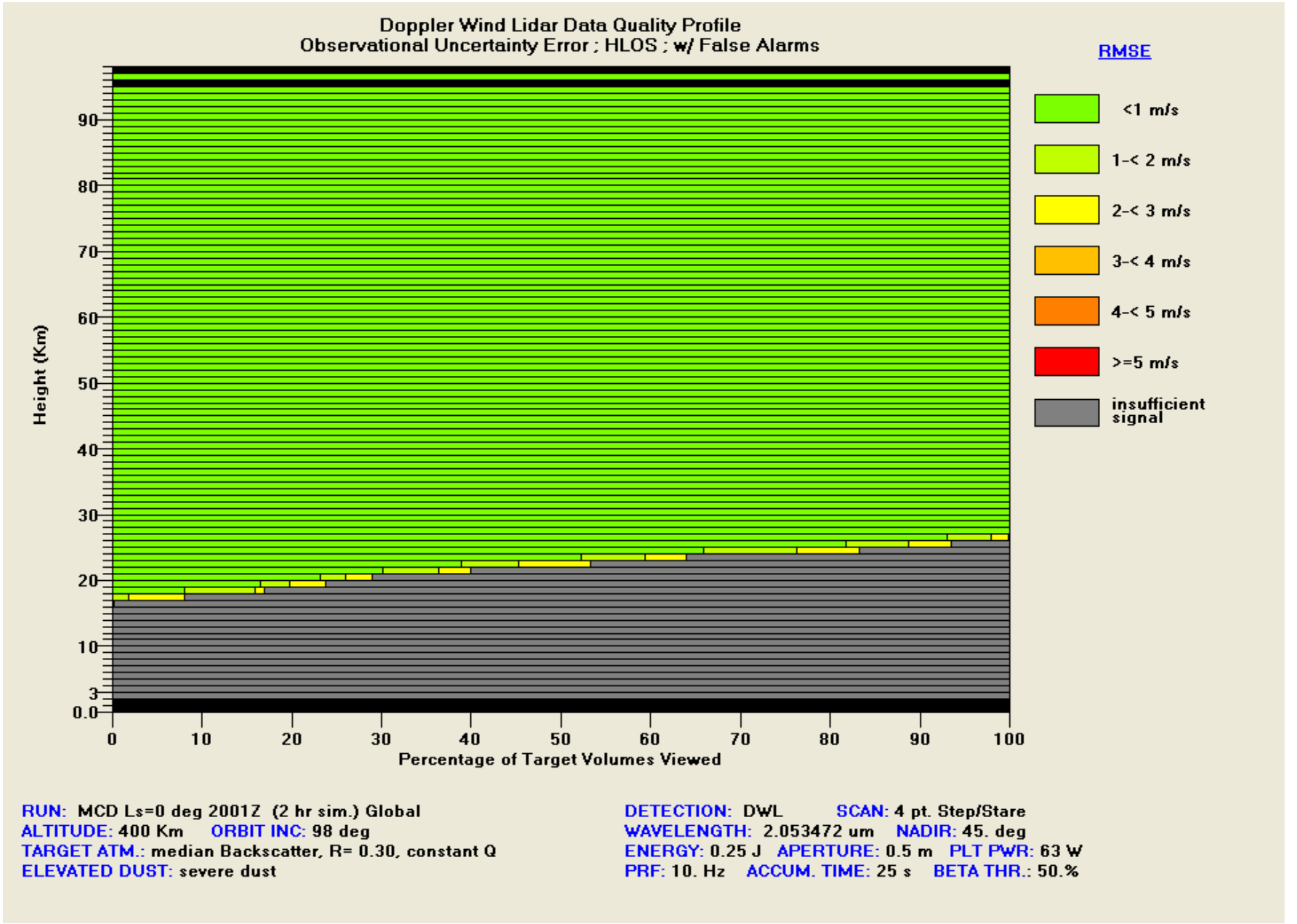
LIDAR SIGNAL PROCESSING INPUTS
Signal proc vel bandwidth (m/s): 15.00
Gross error probability threshold: 0.50
DWL shot processing: accumulation shot processing
Altitude Boundary Level for DWL (km): 3.00
Vertical bin > ABL to accumulate over (km): 1.00
Vertical bin <= ABL to accumulate over (km): 1.00

ATMOSPHERIC INPUTS
Atm. Library: MCD Mars Global Surveyor
Subgrid Scale Variance Option: 9 point
Aerosol Backscatter Option: median
Backscatter Mixing Ratio Option: Constant
Aerosol Concentration: 0.50E+07
Mode Radius (um) Background: 0.30
Elevated Backscatter Mode: user defined
Mode Radius (um) Elevated: 0.00
Elevated Backscatter Mode: Extreme Dust Storm



RUN: MCD Ls=0 deg 2001Z (2 hr sim.) Global
ALTITUDE: 400 Km ORBIT INC: 98 deg
TARGET ATM.: median Backscatter, R= 0.30, constant Q
ELEVATED DUST: user defined R = 0.00 um

DETECTION: DWL SCAN: 4 pt. Step/Stare
WAVELENGTH: 2.053472 um NADIR: 45. deg
ENERGY: 0.25 J APERTURE: 0.5 m PLT PWR: 63 W
PRF: 10. Hz ACCUM. TIME: 25 s BETA THR.: 50.%

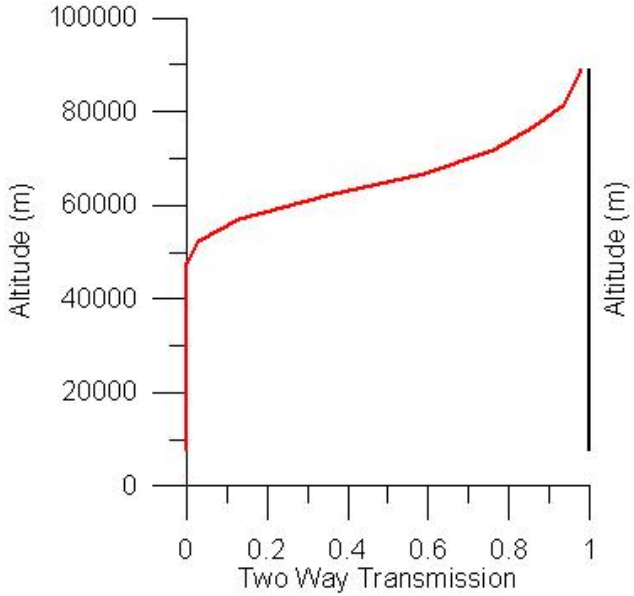

Doppler Wind Lidar Data Quality Profile
Observational Uncertainty Error ; HLOS ; w/ False Alarms
RMSE
<1 m/s
1-< 2 m/s
2-< 3 m/s
3-< 4 m/s
4-< 5 m/s
>=5 m/s
insufficient signal
Height (Km)
90
80
70
60
50
40
30
20
10
3
0.0
0
10
20
30
40
50
60
70
80
90
100
Percentage of Target Volumes Viewed
RUN: MCD Ls=0 deg 2001Z (2 hr sim.) Global
ALTITUDE: 400 Km ORBIT INC: 98 deg
TARGET ATM.: median Backscatter, R= 0.30, constant Q
ELEVATED DUST: severe dust
DETECTION: DWL SCAN: 4 pt. Step/Stare
WAVELENGTH: 2.053472 um NADIR: 45. deg
ENERGY: 0.25 J APERTURE: 0.5 m PLT PWR: 63 W
PRF: 10. Hz ACCUM. TIME: 25 s BETA THR.: 50.%

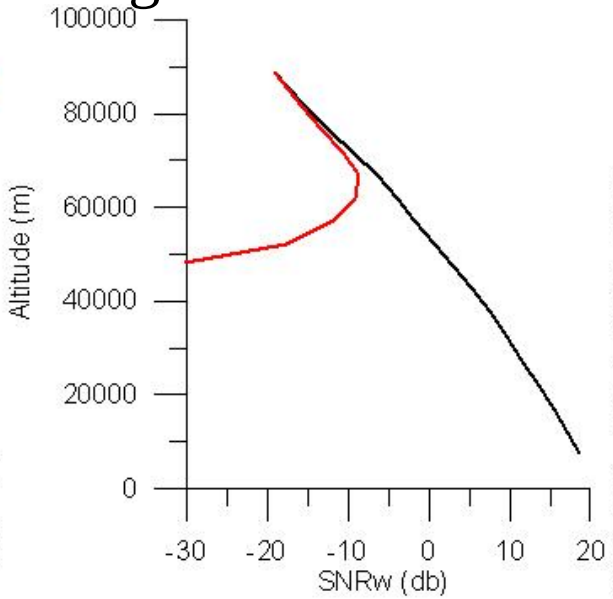
MLSM

Mars DIAL Simulation

Simpson Weather Associates, Inc.

DIAL Single Profile Performance





Off Channel
On Channel

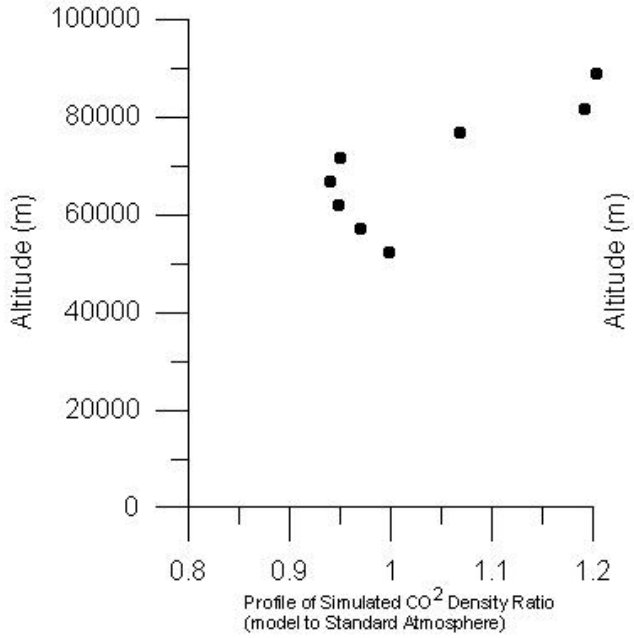
PLATFORM INPUTS
Starting altitude of the satellite (km): 400.00
Starting orbit inclination angle (deg): 98.00

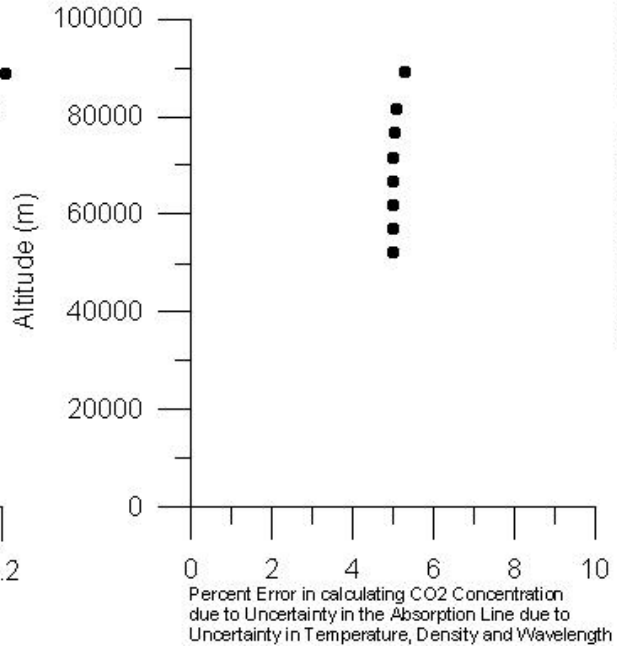
LASER SYSTEM INPUTS
Energy per pulse (j) for DIAL - On Channel : 0.25
Energy per pulse (j) for DIAL - Off Channel: 0.25
Laser wavelength (um) for On Channel: 2.053199
Laser wavelength (um) for Off Channel: 2.053472
Pulse duration (u-sec): 2.00
Prf of the scanner (hz): 10.00

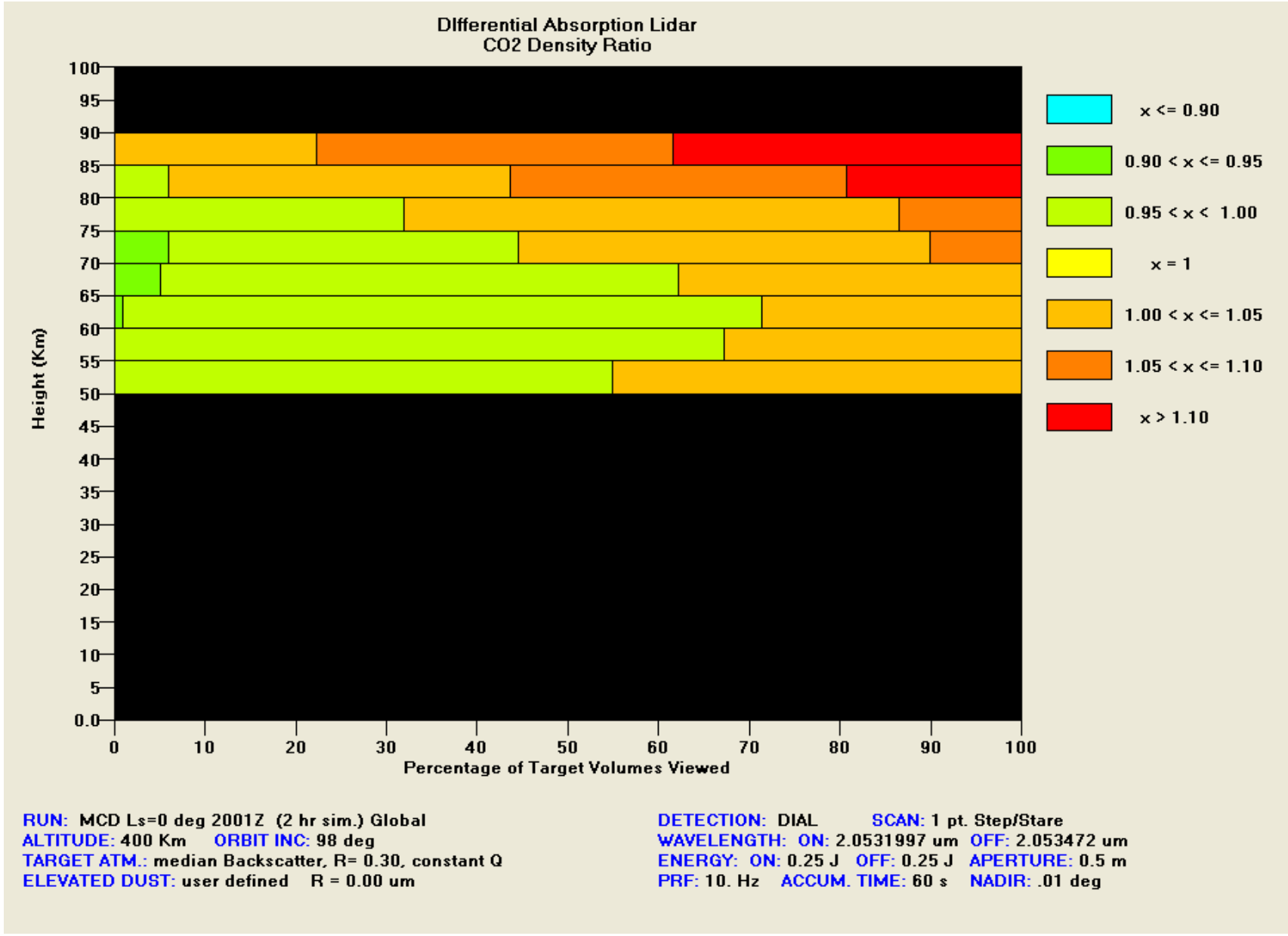
TELESCOPE/SCANNER INPUTS
Scanner shot manager type: step/stare
Diameter of the primary telescope mirror (m): 0.50
Number of discrete azimuths: 1
Nadir scan angle for each azim. ang. (deg): 0.00
Time for a fix/SS beam to fire shots (s): 60.00
Duty cycle of the scan pattern (%): 100.00

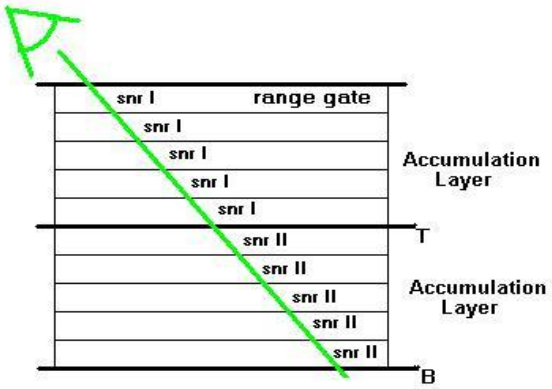
LIDAR SIGNAL PROCESSING INPUTS
DIAL shot processing: accumulation shot processing
Altitude Boundary Level for DWL (km): 5.00
Vertical bin > ABL to accumulate over (km): 5.00
Vertical bin <= ABL to accumulate over (km): 5.00

ATMOSPHERIC INPUTS
Atm. Library: MCD Mars Global Surveyor
Subgrid Scale Variance Option: 9 point
Aerosol Backscatter Option: median
Backscatter Mixing Ratio Option: Constant
Aerosol Concentration: 0.50E+07
Mode Radius (um) Background: 0.30
Elevated Backscatter Mode: user defined
Mode Radius (um) Elevated: 0.00






DIfferential Absorption Lidar
CO2 Density Ratio
Height (Km)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0.0
0
10
20
30
40
50
60
70
80
90
100
Percentage of Target Volumes Viewed
x <= 0.90
0.90 < x <= 0.95
0.95 < x < 1.00
x = 1
1.00 < x <= 1.05
1.05 < x <= 1.10
x > 1.10
RUN: MCD Ls=0 deg 2001Z (2 hr sim.) Global
ALTITUDE: 400 Km ORBIT INC: 98 deg
TARGET ATM.: median Backscatter, R= 0.30, constant Q
ELEVATED DUST: user defined R = 0.00 um
DETECTION: DIAL SCAN: 1 pt. Step/Stare
WAVELENGTH: ON: 2.0531997 um OFF: 2.053472 um
ENERGY: ON: 0.25 J OFF: 0.25 J APERTURE: 0.5 m
PRF: 10. Hz ACCUM. TIME: 60 s NADIR: .01 deg



Accumulated DIAL Products

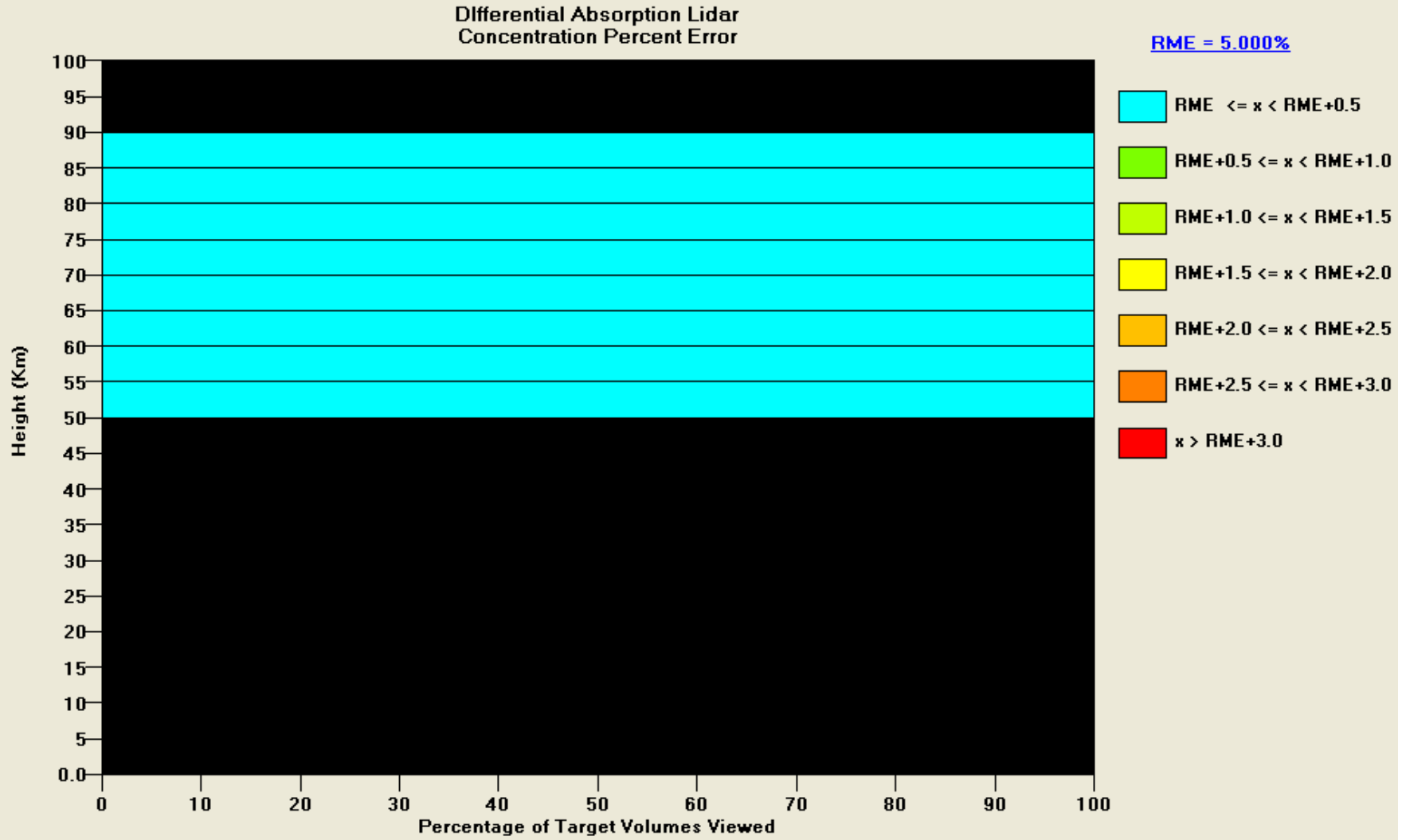
$$\bar{P}on_m = \frac{\sum_t^z Pon_m}{N} \qquad \bar{P}on_s = \frac{\sum_t^z Pon_s}{N}$$

$$\bar{P}off_m = \frac{\sum_t^z Poff_m}{N} \qquad \bar{P}off_s = \frac{\sum_t^z Poff_s}{N}$$

$$\frac{\rho_{co_m^2}}{\rho_{co_s^2}} = \frac{\ln\left[\frac{\bar{P}on_T * \bar{P}off_B}{\bar{P}on_B * \bar{P}off_T}\right]_m}{\ln\left[\frac{\bar{P}on_T * \bar{P}off_B}{\bar{P}on_B * \bar{P}off_T}\right]_s}$$

where

$\bar{P}on_m$	accumulated measured signal product for the on channel
$\bar{P}off_m$	accumulated measured signal product for the off channel
$\bar{P}on_s$	accumulated standard atm. signal product for the on channel
$\bar{P}off_s$	accumulated standard atm. signal product for the off channel
N	number of samples in the grid volume
T and B	top and bottom of the accumulation layer, respectively
$\rho_{co_m^2}$	density measurement product of CO2
$\rho_{co_s^2}$	density standard atm. product of CO2



RUN: MCD Ls=0 deg 2001Z (2 hr sim.) Global
ALTITUDE: 400 Km ORBIT INC: 98 deg
TARGET ATM.: median Backscatter, R= 0.30, constant Q
ELEVATED DUST: user defined R = 0.00 um

DETECTION: DIAL SCAN: 1 pt. Step/Stare
WAVELENGTH: ON: 2.0531997 um OFF: 2.053472 um
ENERGY: ON: 0.25 J OFF: 0.25 J APERTURE: 0.5 m
PRF: 10. Hz ACCUM. TIME: 60 s NADIR: .01 deg

ϕ is the average number of coherently detected photoelectrons per estimate (Frehlich)

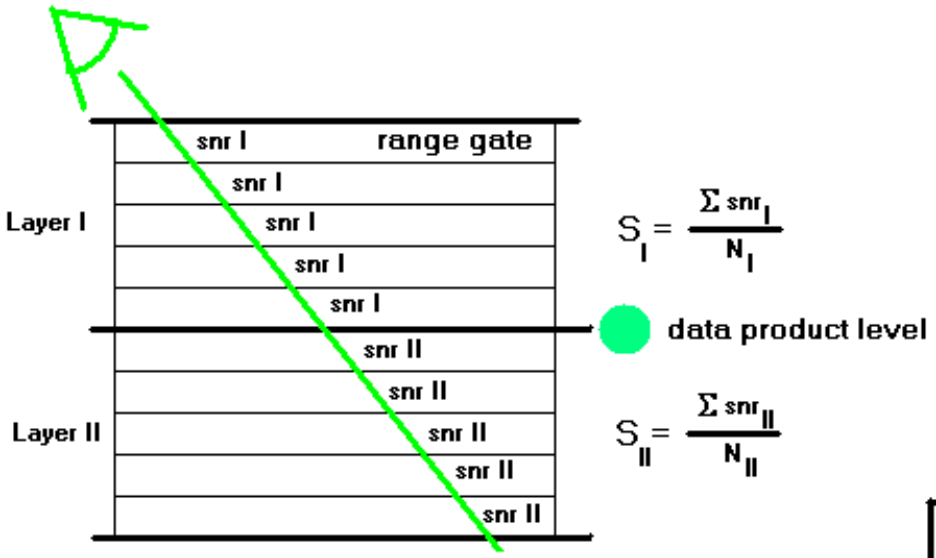
ϕ_{thr} is the user input threshold for ϕ

N is the number of estimates in a grid volume

S is the average signal in a layer

ε is the percent error in calculating CO_2 concentration due to the uncetainty in the absorption line due to temperature, pressure and wavelength uncertainties

For $\phi_{on} > 1$ and $\phi_{off} > 1$



$$S_I = \frac{\Sigma\, snr_I}{N_I}$$

$$S_{II} = \frac{\Sigma\, snr_{II}}{N_{II}}$$

if $\phi_{on} > \phi_{thr}$, then $\omega = 1$

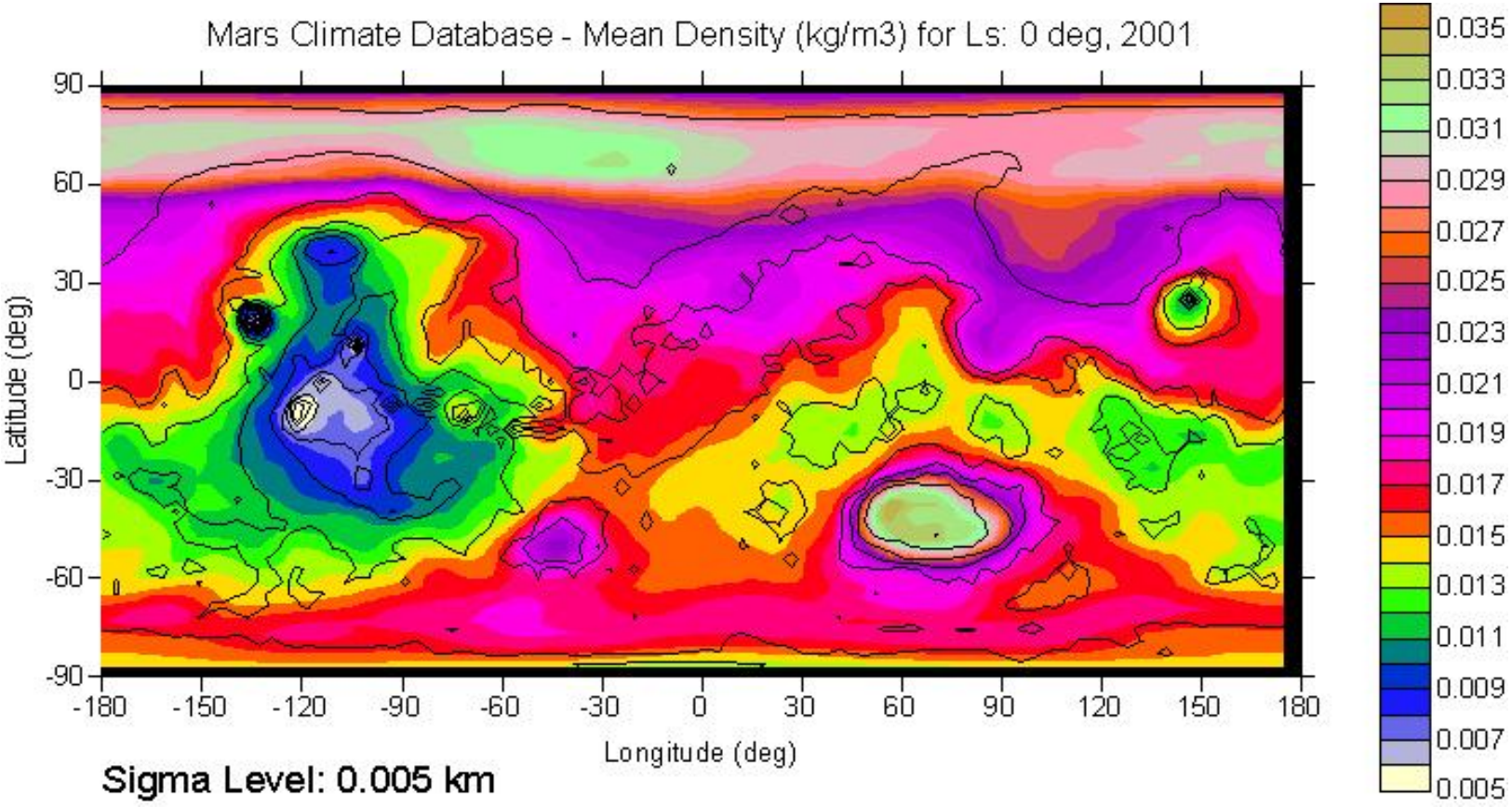
if $1 < \phi_{on} < \phi_{thr}$, then $\omega = (\phi_{thr} + 1) - \phi_{on}$

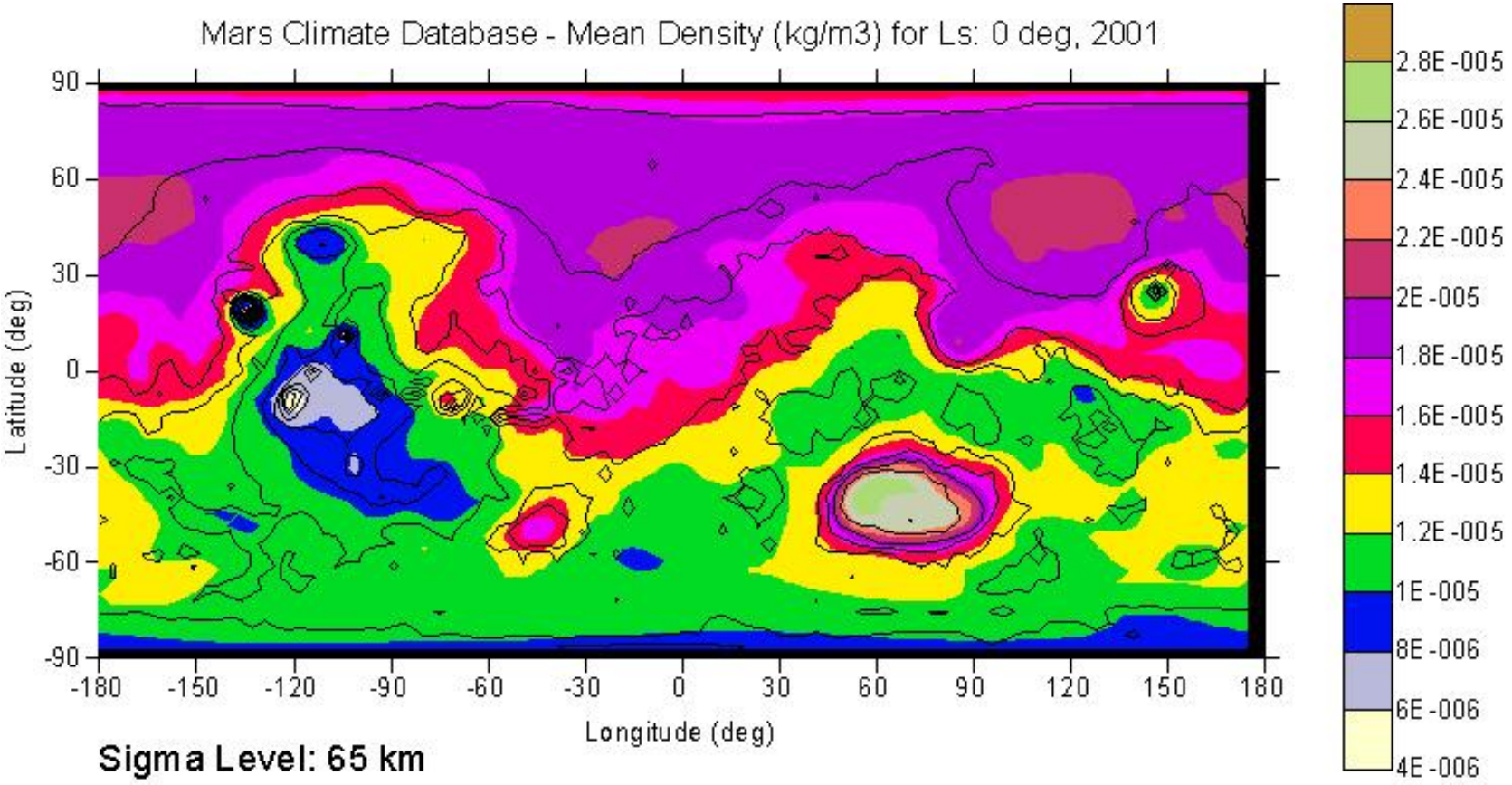
$$Error = \left[\varepsilon^2 + \frac{\omega \left(\frac{1}{N_{I_{on}}} + \frac{1}{N_{II_{on}}} + \frac{1}{N_{I_{off}}} + \frac{1}{N_{II_{off}}} \right)}{\left[\ln \left(\frac{S_{I_{on}} \cdot S_{II_{off}}}{S_{I_{off}} \cdot S_{II_{on}}} \right) \right]^2} \right]^{1/2}$$

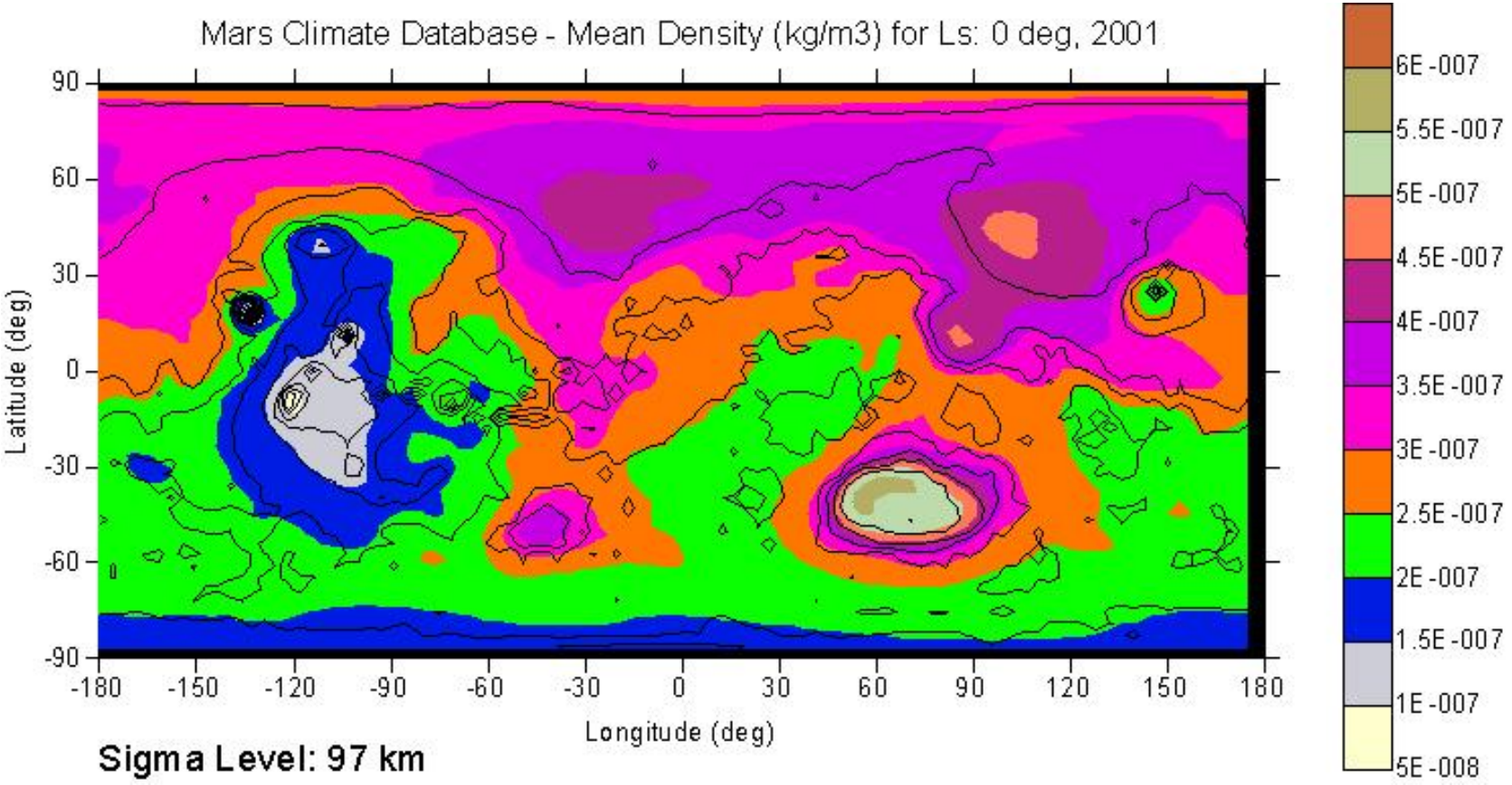
MLSM

Mars Atmosphere Discussions

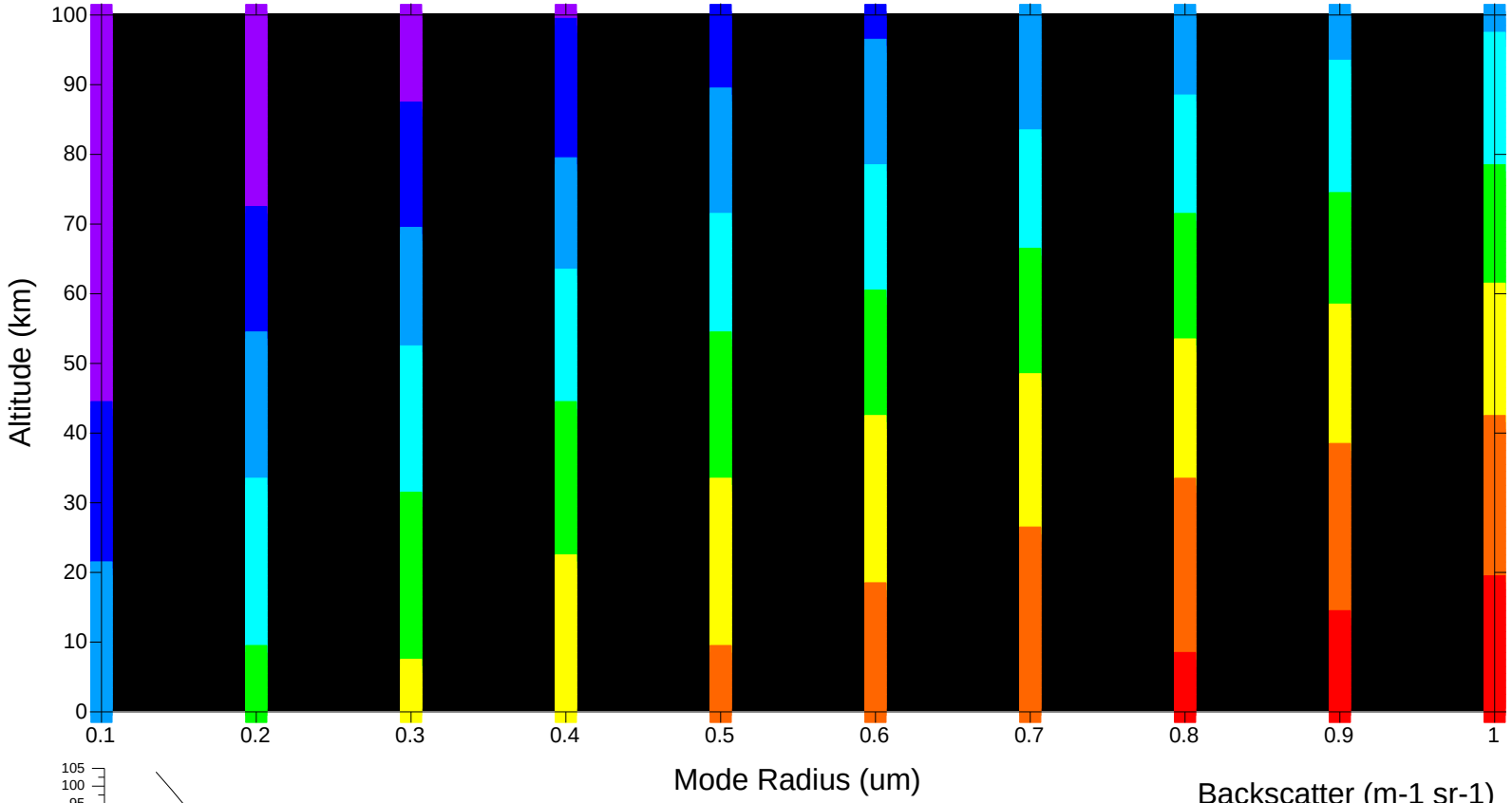
Simpson Weather Associates, Inc.

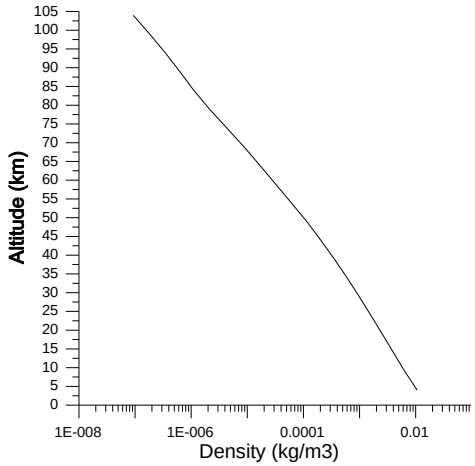

Mars Climate Database - Mean Density (kg/m3) for Ls: 0 deg, 2001
Latitude (deg)
90
60
30
0
-30
-60
-90
-180
-150
-120
-90
-60
-30
0
30
60
90
120
150
180
Longitude (deg)
Sigma Level: 0.005 km
0.035
0.033
0.031
0.029
0.027
0.025
0.023
0.021
0.019
0.017
0.015
0.013
0.011
0.009
0.007
0.005


Mars Climate Database - Mean Density (kg/m3) for Ls: 0 deg, 2001
Latitude (deg)
90
60
30
0
-30
-60
-90
-180
-150
-120
-90
-60
-30
0
30
60
90
120
150
180
Longitude (deg)
Sigma Level: 65 km
2.8E-005
2.6E-005
2.4E-005
2.2E-005
2E-005
1.8E-005
1.6E-005
1.4E-005
1.2E-005
1E-005
8E-006
6E-006
4E-006


Mars Climate Database - Mean Density (kg/m3) for Ls: 0 deg, 2001
90
60
30
0
-30
-60
-90
Latitude (deg)
-180
-150
-120
-90
-60
-30
0
30
60
90
120
150
180
Longitude (deg)
Sigma Level: 97 km
6E-007
5.5E-007
5E-007
4.5E-007
4E-007
3.5E-007
3E-007
2.5E-007
2E-007
1.5E-007
1E-007
5E-008

MARS Aerosol Backscatter for Varying Size Distributions



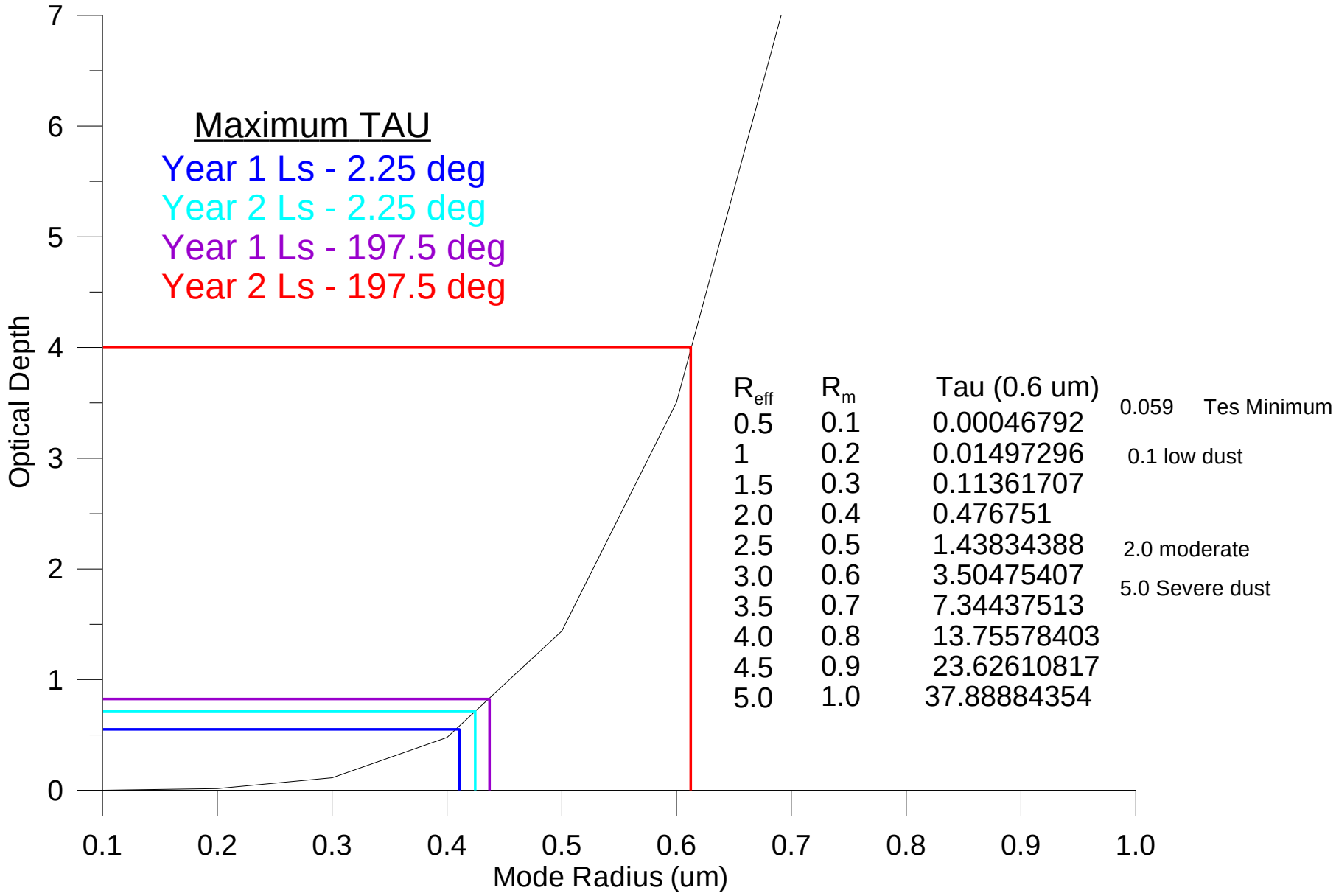


Backscatter (m-1 sr-1)

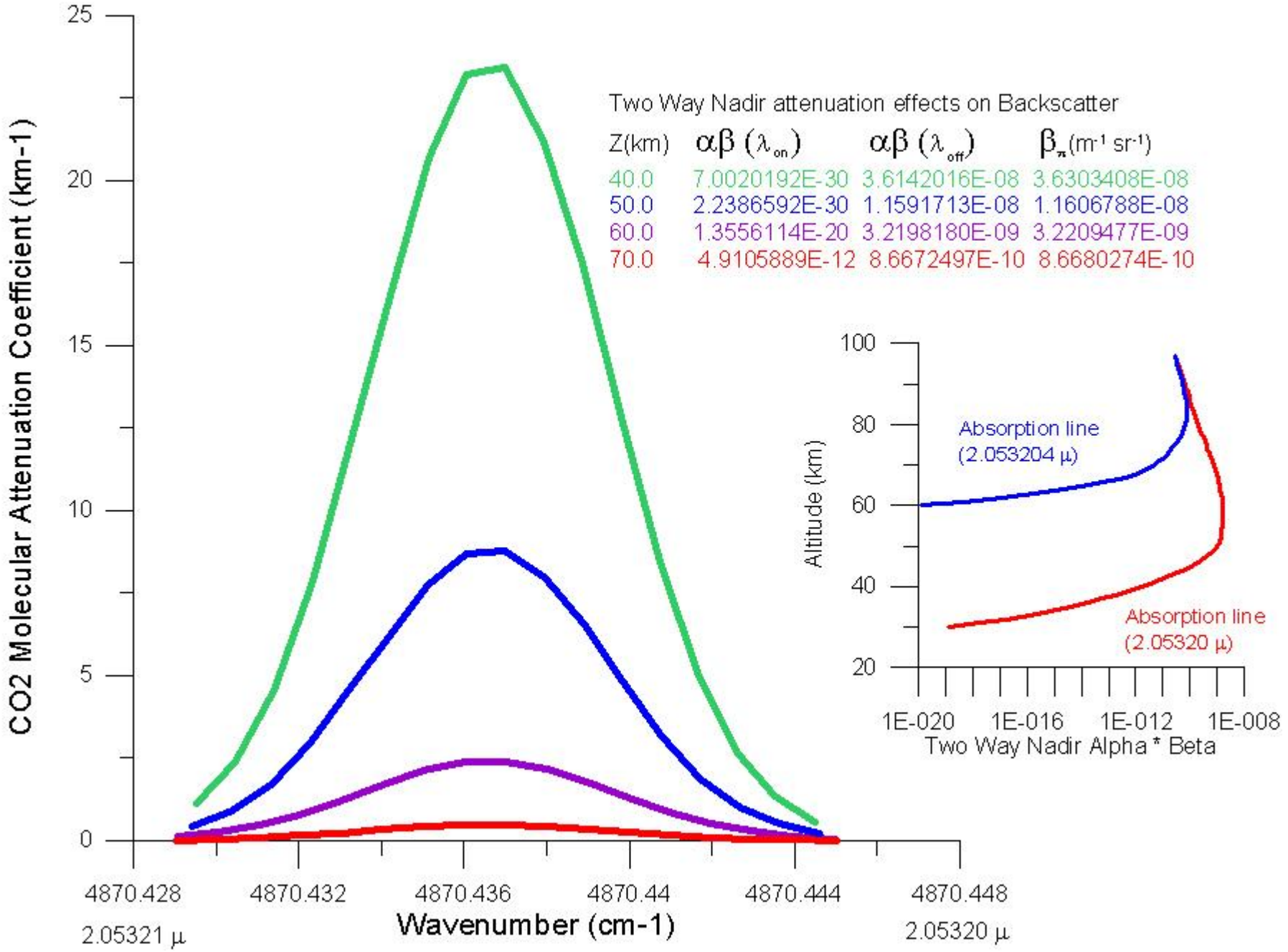
1E-014	1E-010
1E-010	1E-009
1E-009	1E-008
1E-008	1E-007
1E-007	1E-006
1E-006	1E-005
1E-005	1E-004
1E-004	1E-003

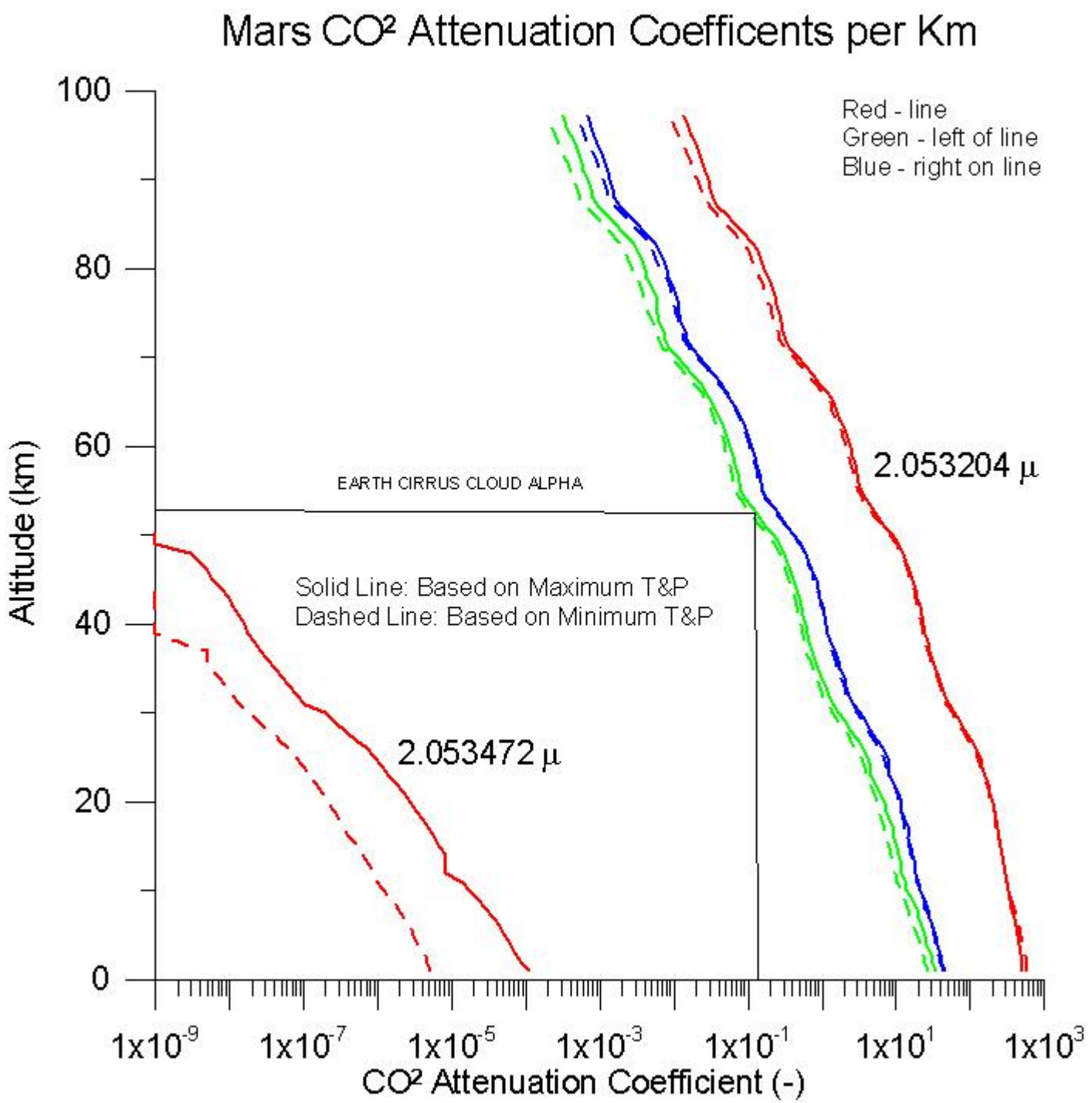
Aerosol Properties

Wavelength: 2.2 um (Bell et al., 1997)
Extinction Efficiency: 3.25 (Bell et al., 1997)
Asymmetry Parameter: 0.63 (Bell et al., 1997)
Haze L - A: 5e6 (Deirmendjian, 1969)
Alpha: 2.0 (Toon et al, 1977)
Gamma: 0.5 (Toon et al, 1977)


Maximum TAU
Year 1 Ls - 2.25 deg
Year 2 Ls - 2.25 deg
Year 1 Ls - 197.5 deg
Year 2 Ls - 197.5 deg
Optical Depth
Mode Radius (um)
0
1
2
3
4
5
6
7
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Reff Rm Tau (0.6 um)
0.5 0.1 0.00046792
1 0.2 0.01497296
1.5 0.3 0.11361707
2.0 0.4 0.476751
2.5 0.5 1.43834388
3.0 0.6 3.50475407
3.5 0.7 7.34437513
4.0 0.8 13.75578403
4.5 0.9 23.62610817
5.0 1.0 37.88884354
0.059 Tes Minimum
0.1 low dust
2.0 moderate
5.0 Severe dust

Wavelength spread of CO2 Molecular Attenuation Coefficient (km-1) as a function of Altitude




Mars CO² Attenuation Coefficents per Km
Red - line
Green - left of line
Blue - right on line
2.053204 μ
EARTH CIRRUS CLOUD ALPHA
Solid Line: Based on Maximum T&P
Dashed Line: Based on Minimum T&P
2.053472 μ
Altitude (km)
100
80
60
40
20
0
1x10-9
1x10-7
1x10-5
1x10-3
1x10-1
1x101
1x103
CO² Attenuation Coefficient (-)

Conclusion

- Equation modifications
- Trade Studies
- MLSM wrap-up