The Environment's Effects on Solar Radiation

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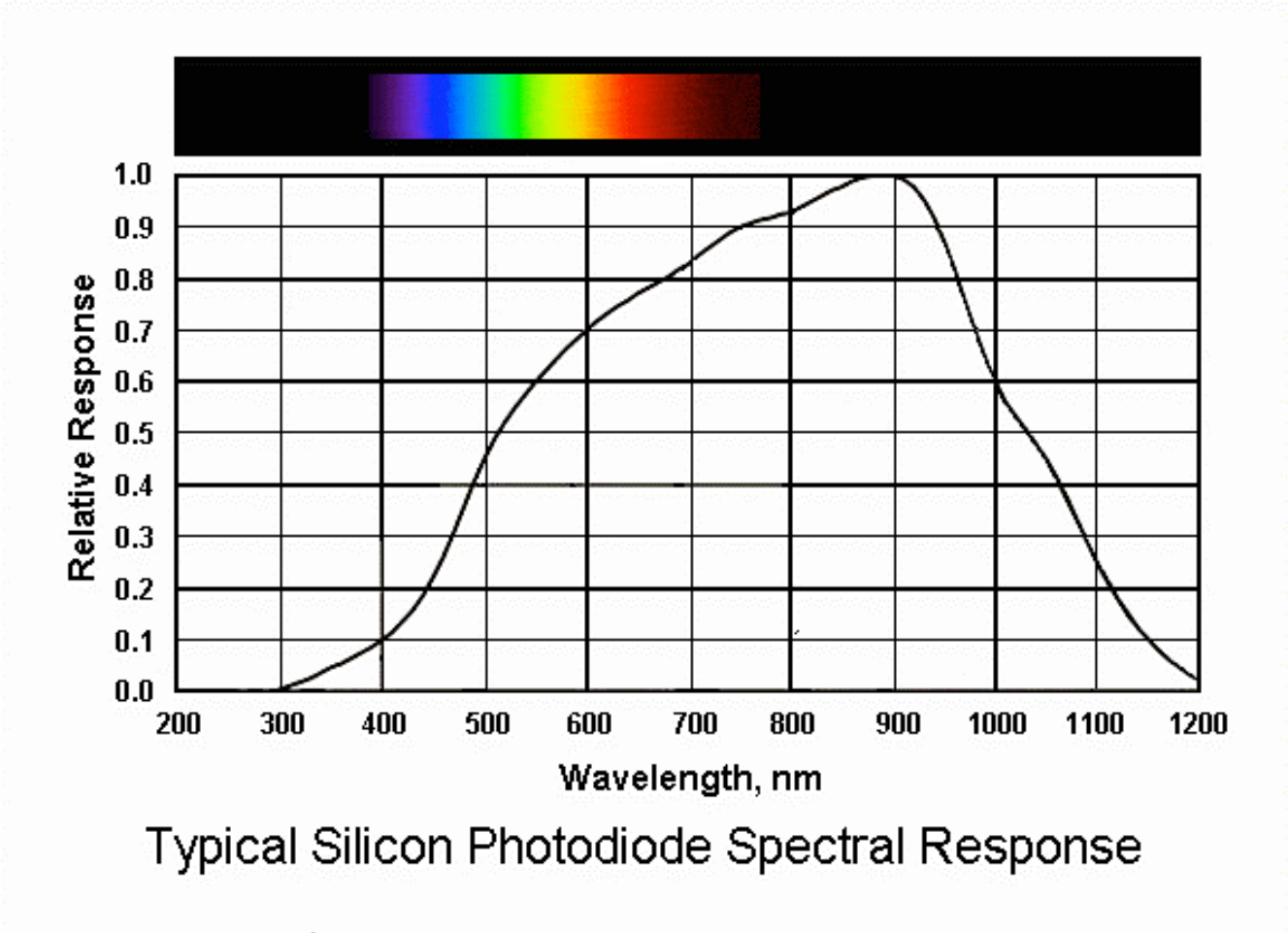
Things considered in talk

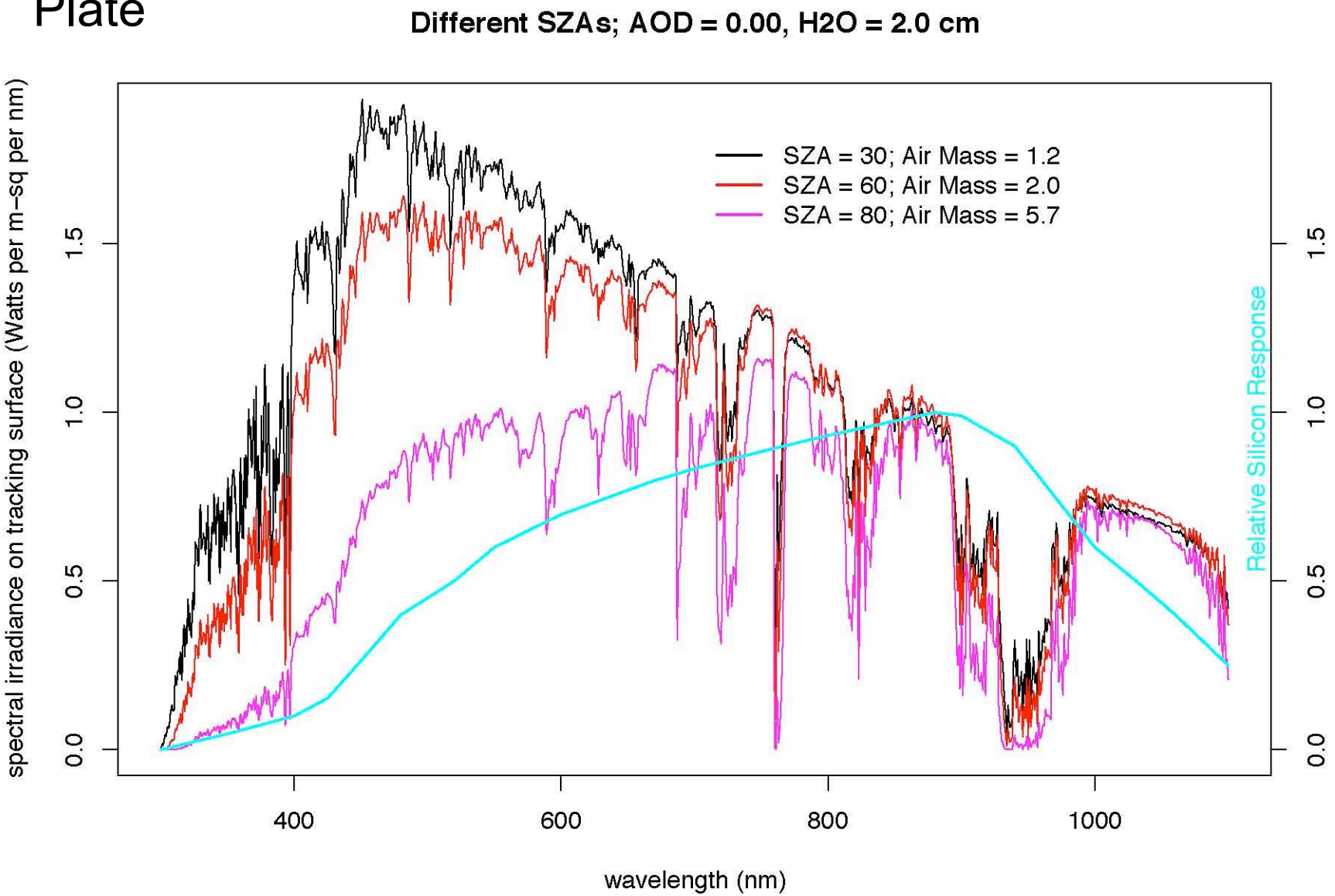
- Assume silicon photovoltaic spectral response
- Compare concentration and flat panels
- Sun-Earth distance changes (min distance Jan; max July-7% range in irradiance)
- Issues when sky is clear (O_3, Rayleigh scattering, H_2O, surface reflectivity, aerosols)
- Albedo or surface reflectivity
- Aerosols with volcanoes as a special case
- Cirrus → Optically thick clouds
- Summary of environmental siting issues

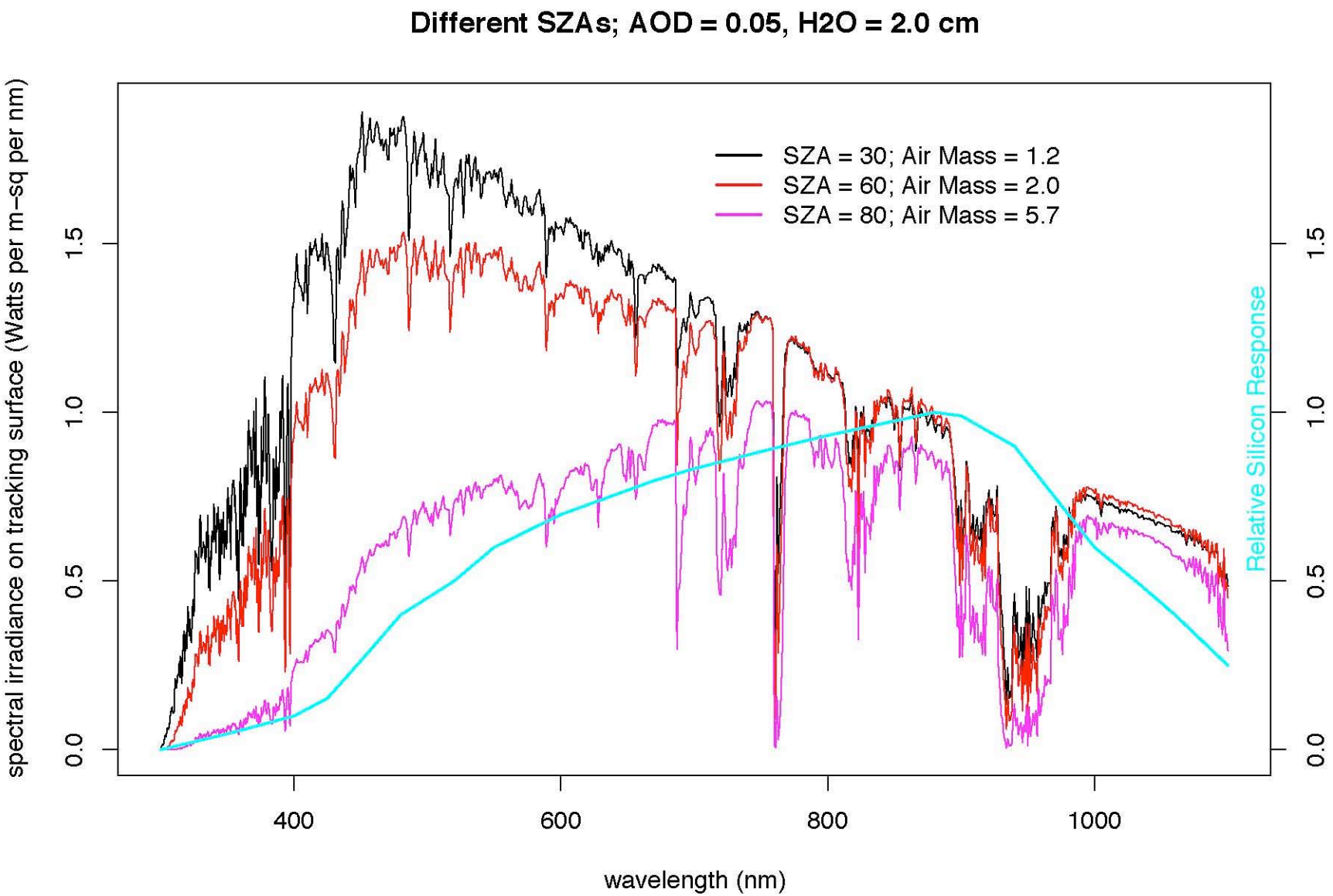


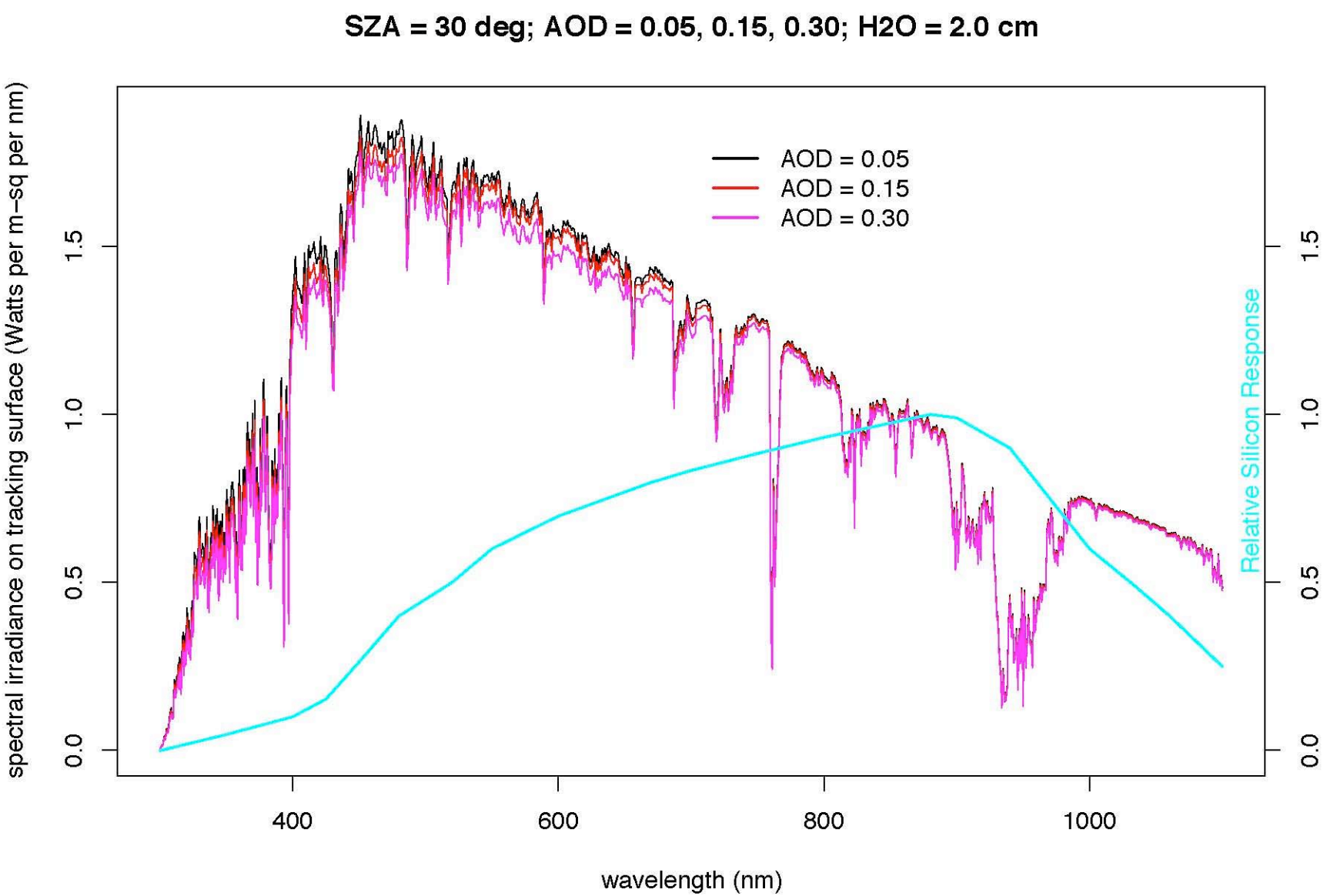
Typical Silicon Photodiode Spectral Response

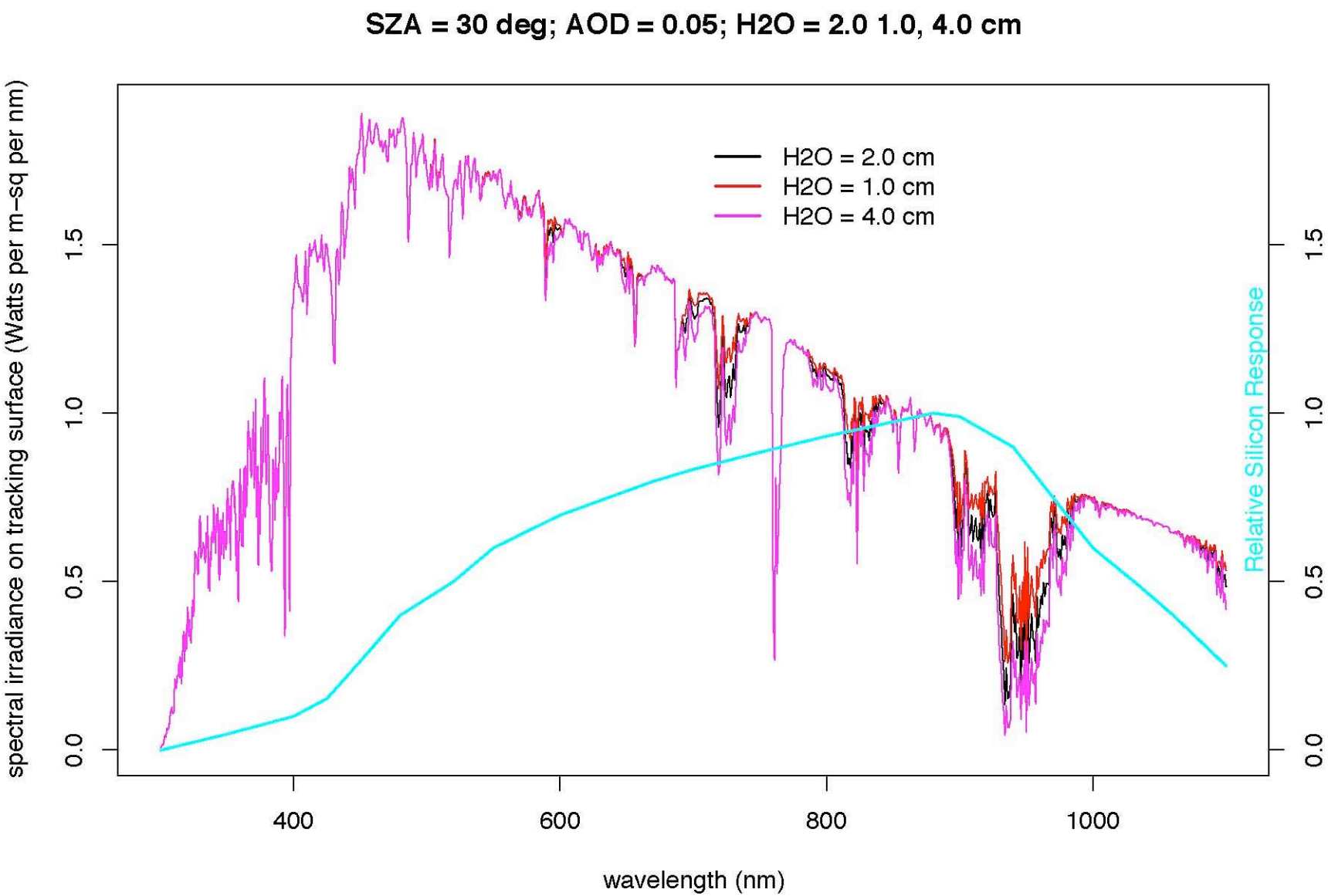
Figure is from members.misty.com/don/laserioi.htm

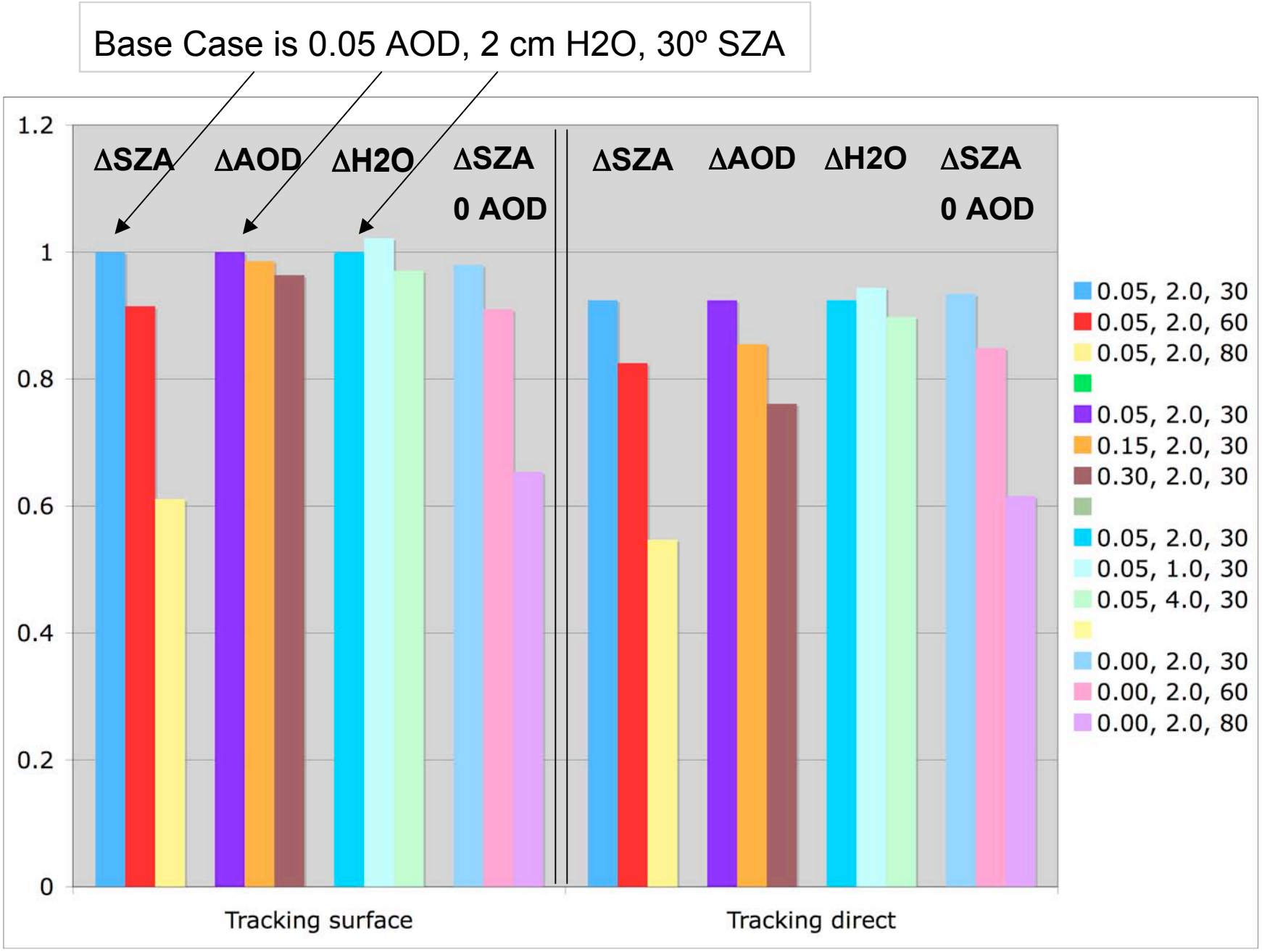
Tracking Flat Plate



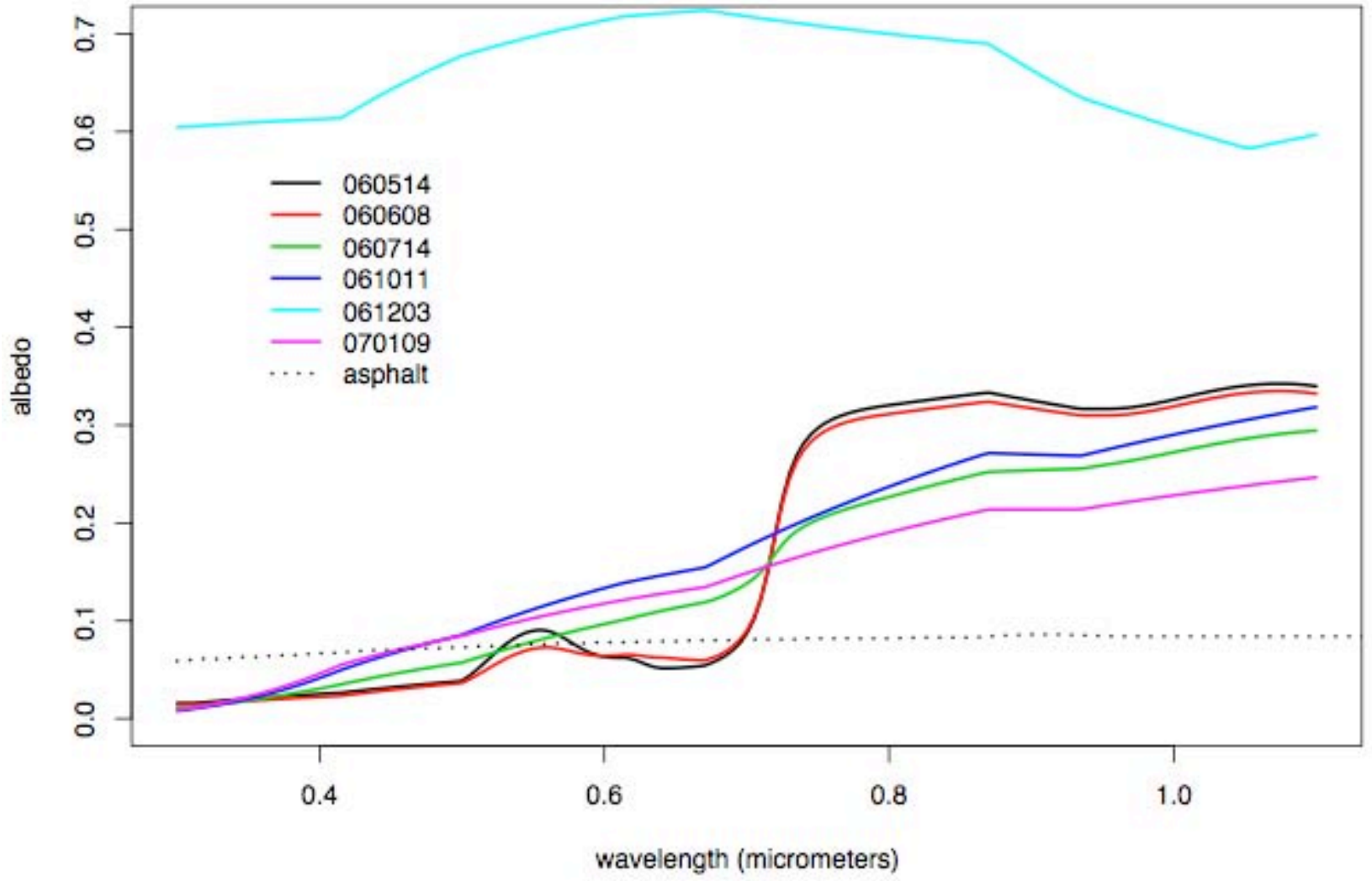

Different SZAs; AOD = 0.05, H2O = 2.0 cm
SZA = 30; Air Mass = 1.2
SZA = 60; Air Mass = 2.0
SZA = 80; Air Mass = 5.7
spectral irradiance on tracking surface (Watts per m−sq per nm)
Relative Silicon Response
wavelength (nm)
0.0
0.5
1.0
1.5
400
600
800
1000

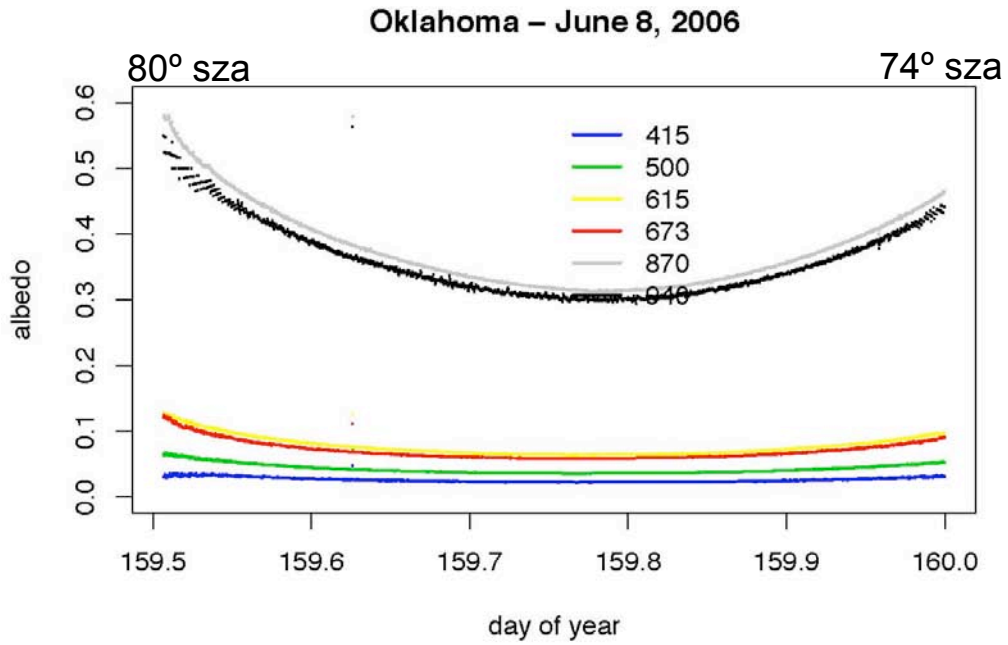

SZA = 30 deg; AOD = 0.05, 0.15, 0.30; H2O = 2.0 cm
AOD = 0.05
AOD = 0.15
AOD = 0.30
spectral irradiance on tracking surface (Watts per m−sq per nm)
Relative Silicon Response
wavelength (nm)
0.0
0.5
1.0
1.5
400
600
800
1000

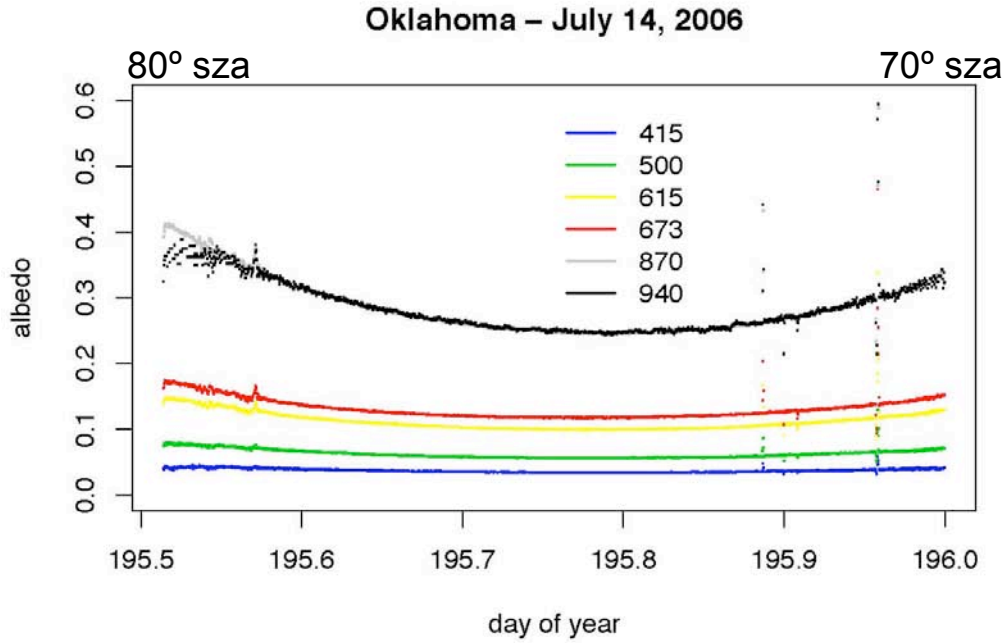

SZA = 30 deg; AOD = 0.05; H2O = 2.0 1.0, 4.0 cm
H2O = 2.0 cm
H2O = 1.0 cm
H2O = 4.0 cm
spectral irradiance on tracking surface (Watts per m−sq per nm)
Relative Silicon Response
wavelength (nm)
0.0
0.5
1.0
1.5
400
600
800
1000

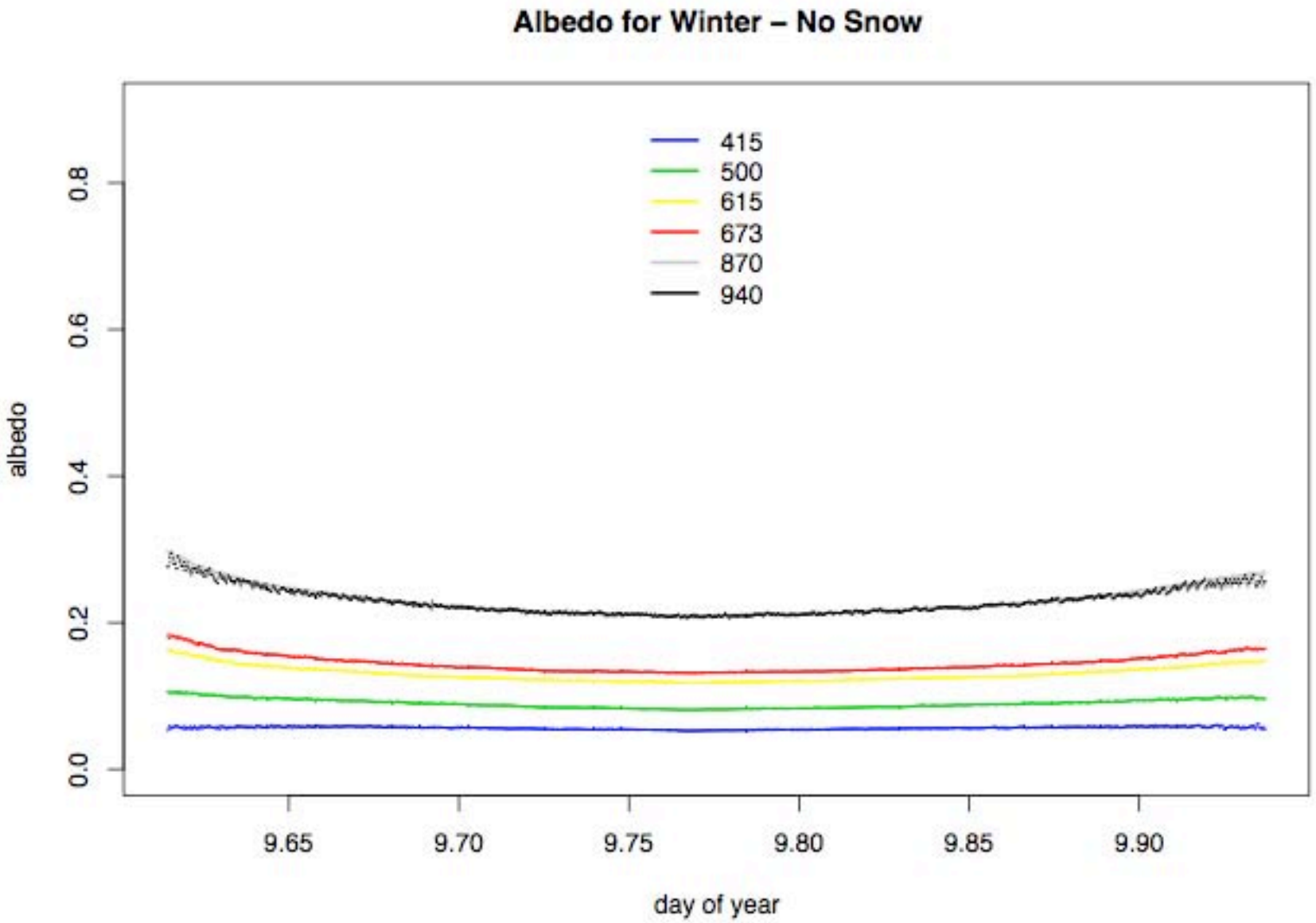

Base Case is 0.05 AOD, 2 cm H2O, 30º SZA
ΔSZA
ΔAOD
ΔH2O
ΔSZA
0 AOD
ΔSZA
ΔAOD
ΔH2O
ΔSZA
0 AOD
1.2
1
0.8
0.6
0.4
0.2
0
Tracking surface
Tracking direct
0.05, 2.0, 30
0.05, 2.0, 60
0.05, 2.0, 80
0.05, 2.0, 30
0.15, 2.0, 30
0.30, 2.0, 30
0.05, 2.0, 30
0.05, 1.0, 30
0.05, 4.0, 30
0.00, 2.0, 30
0.00, 2.0, 60
0.00, 2.0, 80

Albedos Based on Six Spectral Filter Measurements Above Crop and Pasture




Oklahoma – June 8, 2006
80º sza
74º sza
albedo
0.0
0.1
0.2
0.3
0.4
0.5
0.6
415
500
615
673
870
940
159.5
159.6
159.7
159.8
159.9
160.0
day of year

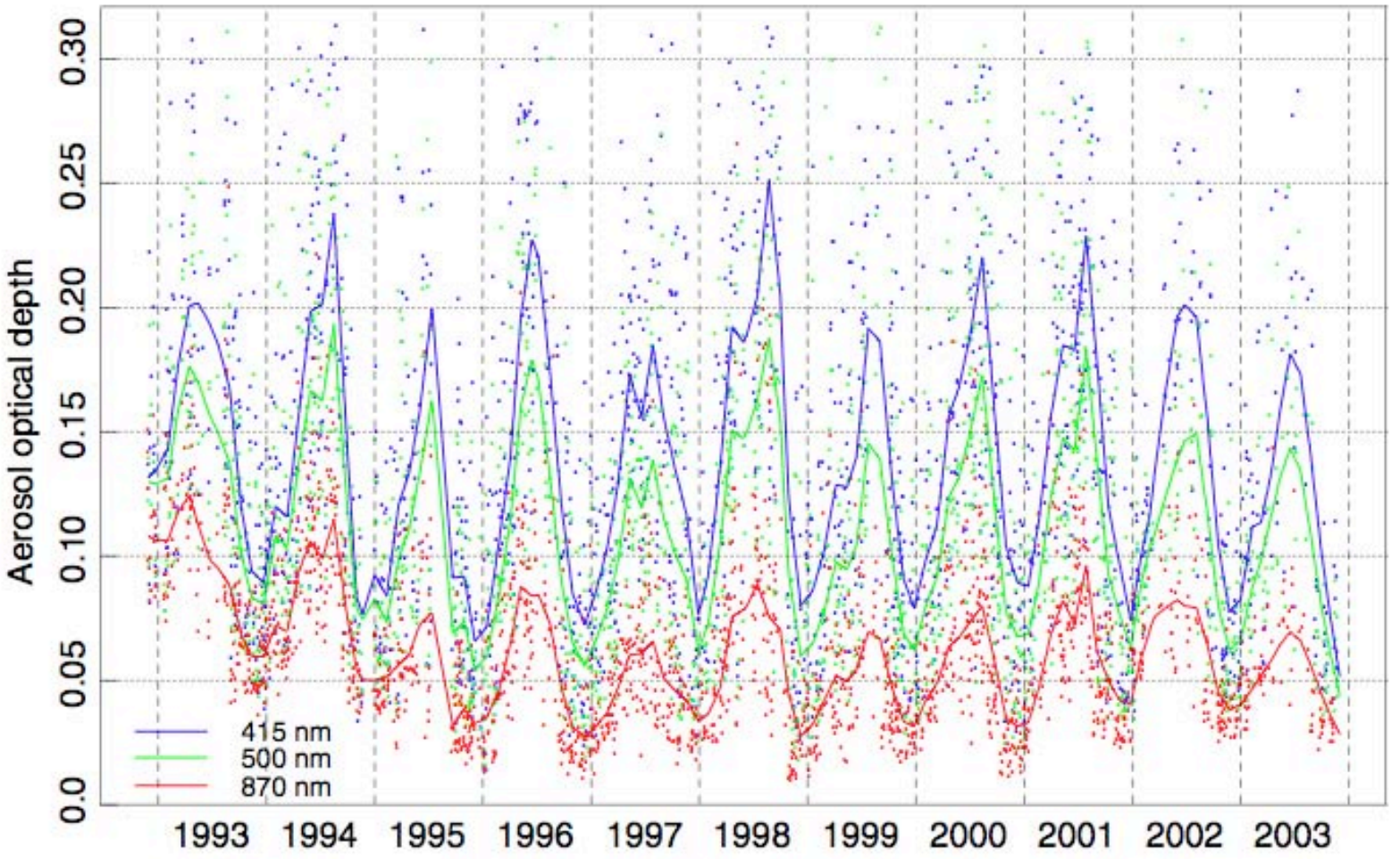

Oklahoma – July 14, 2006
80º sza
70º sza
albedo
0.0
0.1
0.2
0.3
0.4
0.5
0.6
415
500
615
673
870
940
195.5
195.6
195.7
195.8
195.9
196.0
day of year


Albedo for Winter – No Snow
415
500
615
673
870
940
albedo
0.0
0.2
0.4
0.6
0.8
9.65
9.70
9.75
9.80
9.85
9.90
day of year

AEROSOL OPTICAL DEPTH

Determined by sunphotometry

North central Oklahoma - Daily average at three wavelengths



J. Michalsky et al., JGR, 2001

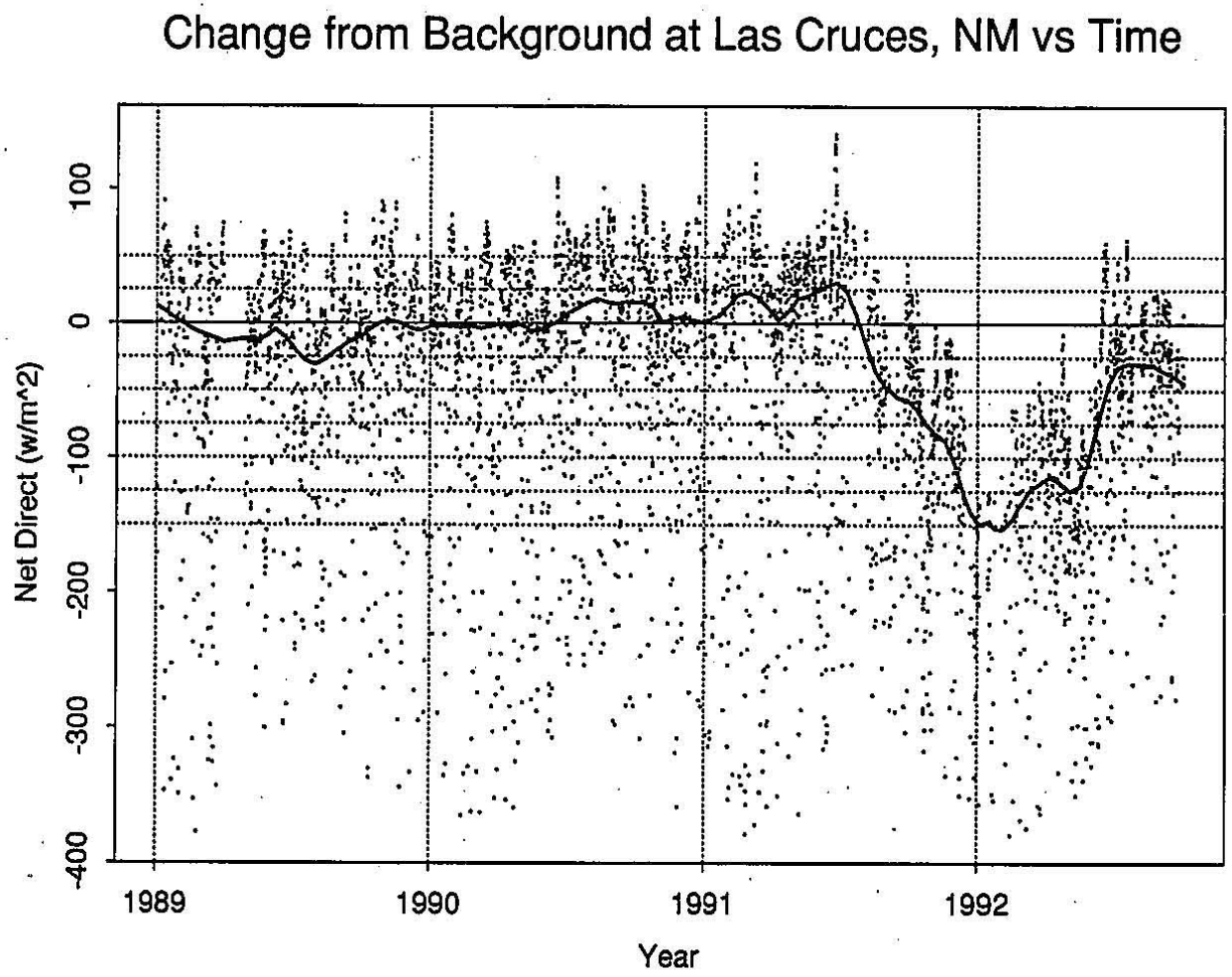
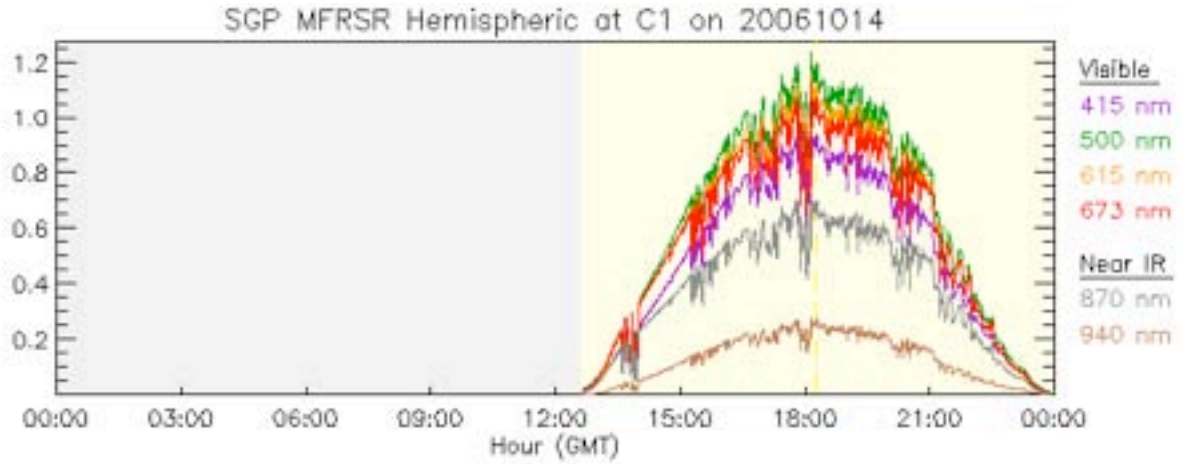
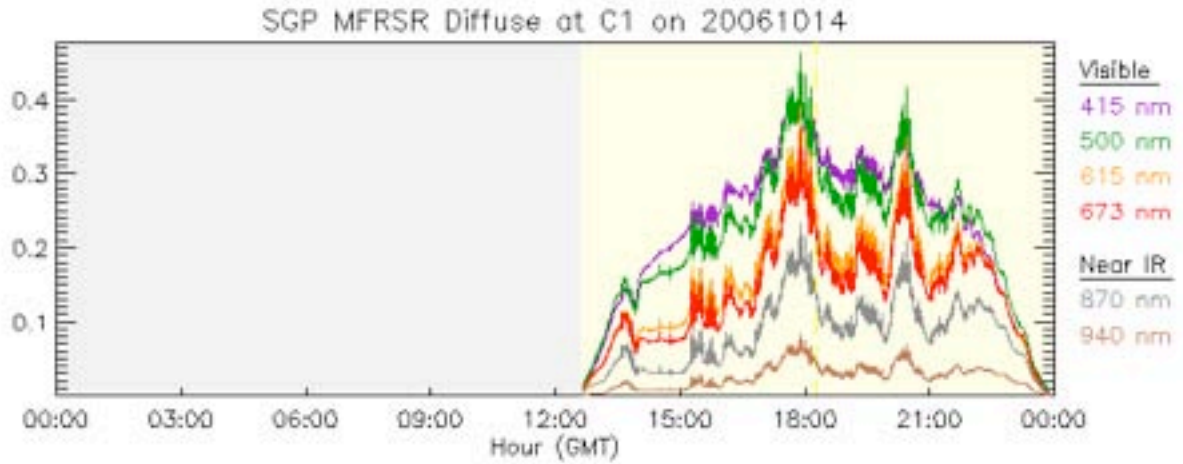


Fig. 4. Time series plot of Fig. 2 with background from Fig. 3 removed according to the time of year the data were measured. Smoothed line is robust estimate of net change with approximately monthly time resolution.

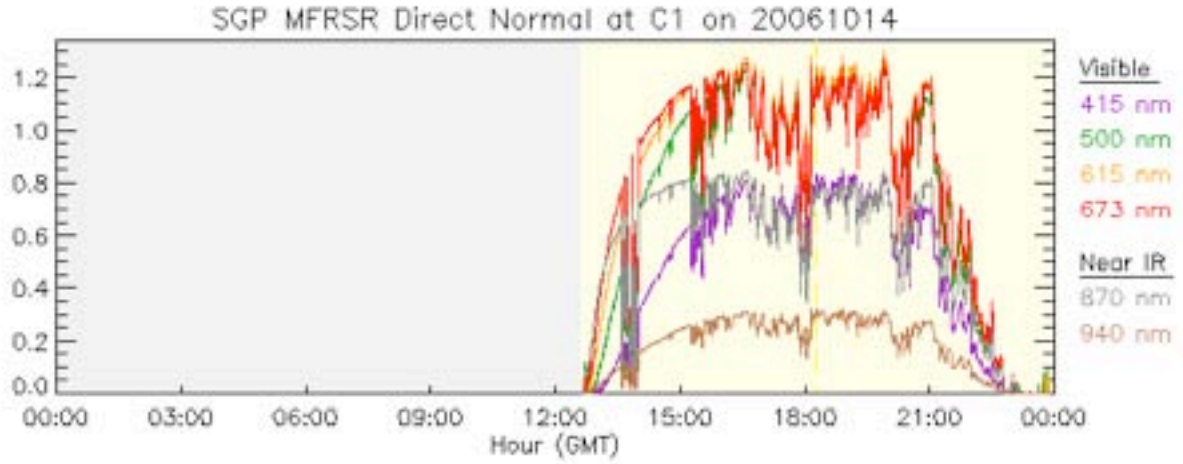
CIRRUS

Total and Diffuse on Horizontal

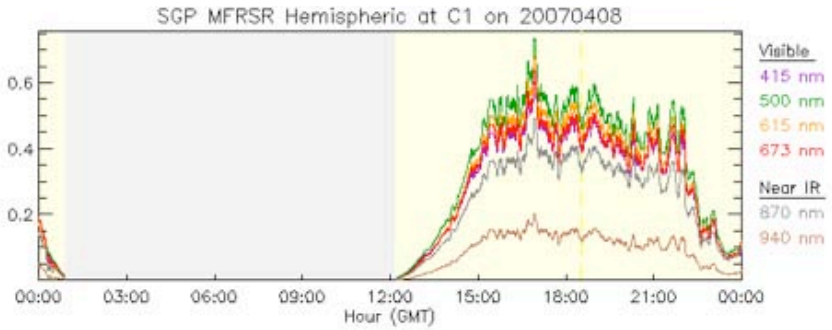


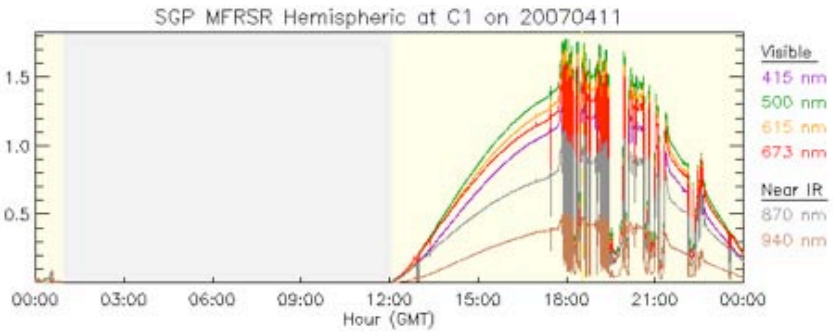


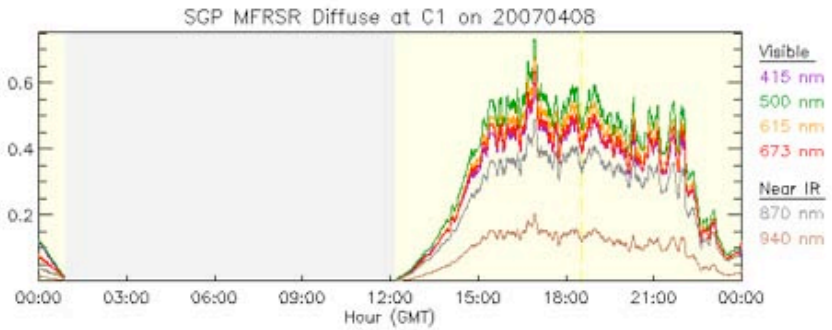
Direct Normal

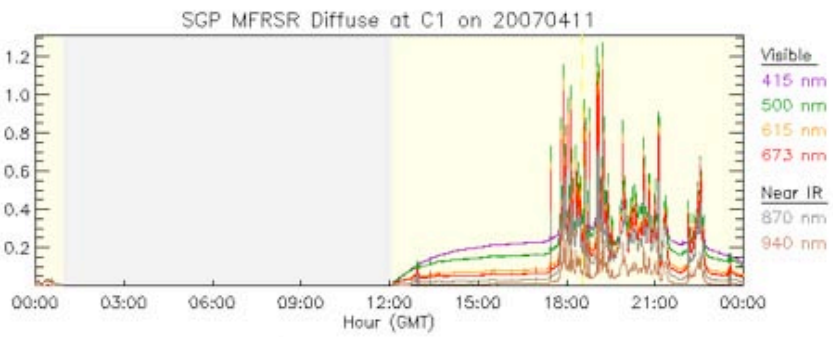


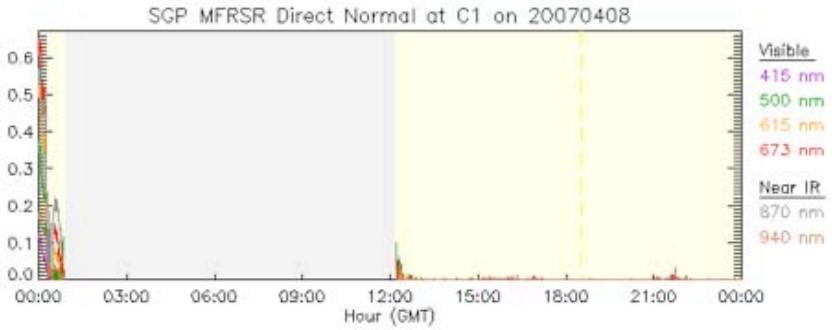
Total and Diffuse on Horizontal

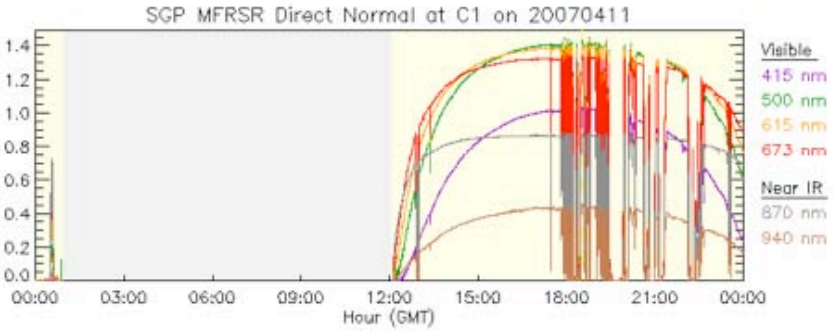




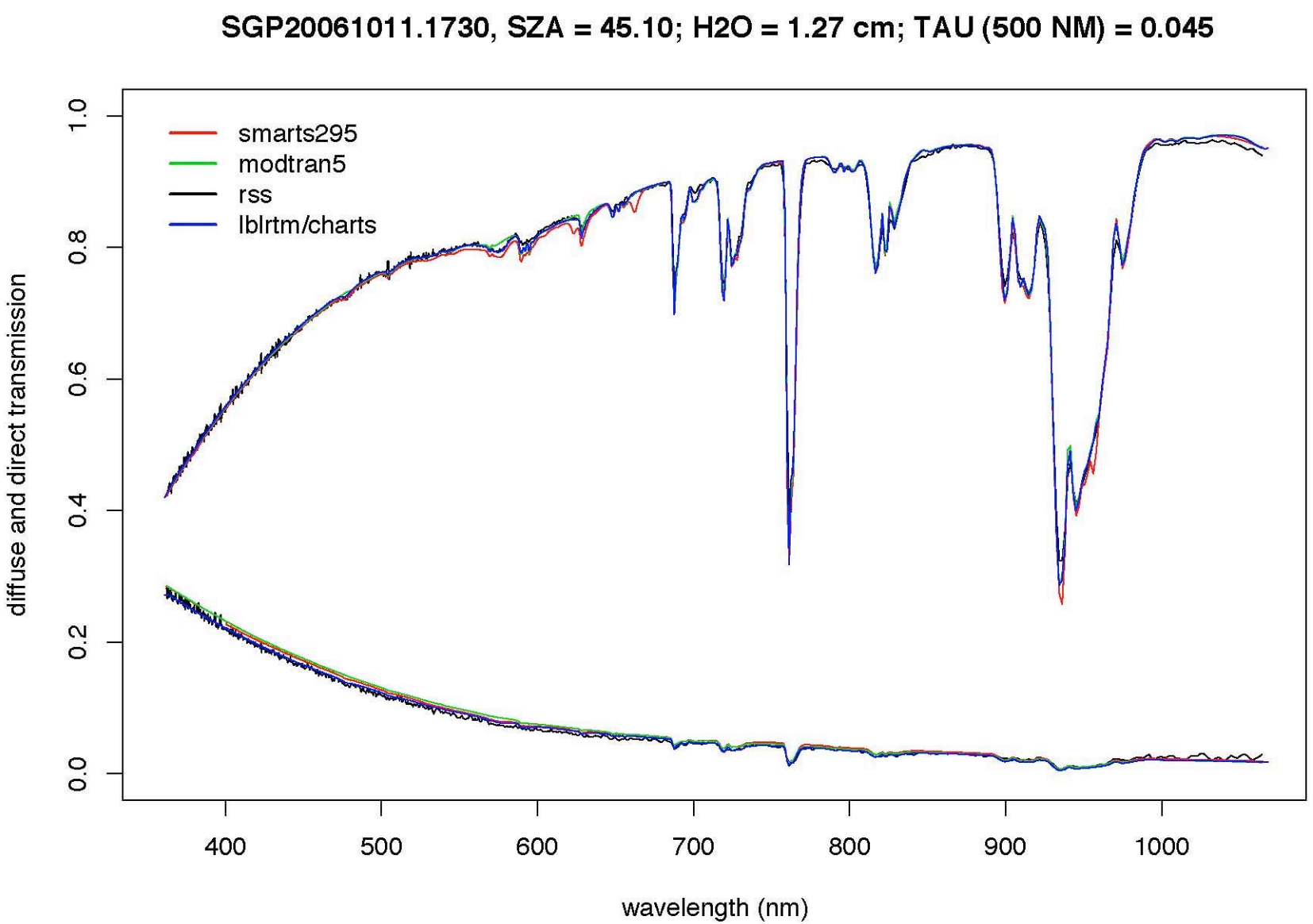








Note: Deploy arrays to point up for overcast conditions


SGP20061011.1730, SZA = 45.10; H2O = 1.27 cm; TAU (500 NM) = 0.045
smarts295
modtran5
rss
lblrtm/charts
diffuse and direct transmission
0.0
0.2
0.4
0.6
0.8
1.0
400
500
600
700
800
900
1000
wavelength (nm)

Environmental Considerations - Summary

- Number of cloudy days and cloud optical thicknesses
- With spectral or broadband measurements can do cloud optical depth assessment for site
- Aerosol optical depths
- Albedo of surroundings
- Do power needs coincide with availability of solar
- Response time of system to irradiance changes
- Spectral response of preferred PV
- Concentration versus flat plate
- Modeling clear-sky is effective if you have basic measurements of AOD, albedo, and H_2O