# TEMPO & GOES-R synergy update and GEO-TASO aerosol retrieval

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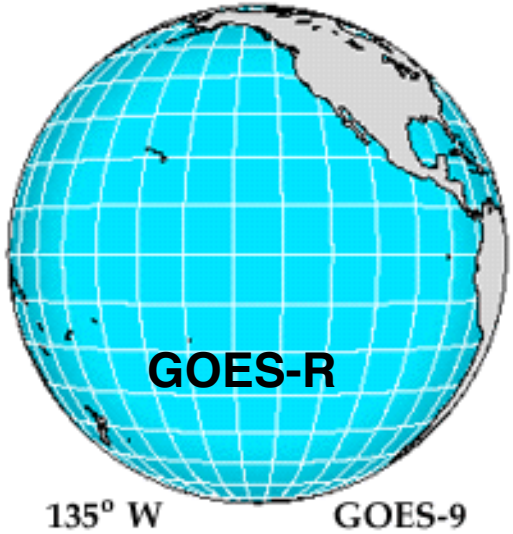



# GOES-R
# to be launched in Oct. 2015

## ABI: Advanced Baseline Imager

**Table 1. Summary of the wavelengths, resolution, and sample use and heritage instrument(s) of the ABI bands. The minimum and maximum wavelength range represent the full width at half maximum (FWHM or 50%) points. [The Instantaneous Geometric Field Of View (IGFOV).]**

| Future GOES imager (ABI) band | Wavelength range (μm) | Central wavelength (μm) | Nominal subsatellite IGFOV (km) | Sample use | Heritage instrument(s) |
|---|---|---|---|---|---|
| 1 | 0.45–0.49 | 0.47 | 1 | Daytime aerosol over land, coastal water mapping | MODIS |
| 2 | 0.59–0.69 | 0.64 | 0.5 | Daytime clouds fog, insolation, winds | Current GOES imager/ sounder |
| 3 | 0.846–0.885 | 0.865 | 1 | Daytime vegetation/burn scar and aerosol over water, winds | VIIRS, spectrally modified AVHRR |
| 4 | 1.371–1.386 | 1.378 | 2 | Daytime cirrus cloud | VIIRS, MODIS |
| 5 | 1.58–1.64 | 1.61 | 1 | Daytime cloud-top phase and particle size, snow | VIIRS, spectrally modified AVHRR |
| 6 | 2.225–2.275 | 2.25 | 2 | Daytime land/cloud properties, particle size, vegetation, snow | VIIRS, similar to MODIS |
| 7 | 3.80–4.00 | 3.90 | 2 | Surface and cloud, fog at night, fire, winds | Current GOES imager |

from Schmit et al., 2005.

# ABI Capability

| | ABI | Current GOES Imager |
|---|---|---|
| Spectral Coverage | 16 bands | 5 bands |
| Spatial Resolution | | |
| 0.64 µm Visible | 0.5 km | ~ 1 km |
| Other visible/near-IR | 1.0 km | n/a |
| Bands (>2 µm) | 2 km | ~ 4 km |
| Spatial Coverage | | |
| Full Disk | 4 per hour | Scheduled (3 hrly) |
| CONUS | 12 per hour | ~4 per hour |
| Mesoscale | Every 30 sec | n/a |
| Visible (reflective bands) | | |
| On-orbit calibration | Yes | No |

http://www.goes-r.gov/

# Strategy for Retrieval Algorithm

- Algorithm development strategy
  - Forward thinking: the GOES+TEMPO synergy algorithm is for aerosol science 5-8 years from now.
  - Holistic thinking: aerosol will affect O3 and other gas retrieval in UV + Vis gas retrieval algorithm; likewise, gas affects aerosol retrieval.
  - Think about users: satellite data provides a constraint, but can not provide all information users needed. Getting the data is not a key question; the key is the uncertainty associated with each retrieval and how does that help what users already have, in places where obs. data is not available. Recall clouds are there 70% of the time. A big community to use these data will modelers and data assimilation folks.
  - Think about validation: link retrieval to what can be measured.
  - Think about STM: climate or air pollution?

# Progress for Retrieval Algorithm

- What we have been developed so far:
  - A inversion/optimization framework that is consistent with what is used for TEMPO O3 retrievals.
  - Seek to provide uncertainty for each individual retrievals.
  - State-of-the-art treatment of gas absorption
  - Tested with AERONET sky radiance so far; Put physically-based constraints to ensure retrieval smoothness and reduce unphysical outliers.
  - Used with GEOS-Chem to provide satellite simulator for answering OSSE-type questions (e.g., from AOD → emission).

- Decision has not been made; some can not be answered without further studies:
  - Treatment of surface (there were multi-ways to do it, discussed later)
  - The role of priori knowledge for the retrieval: e.g., aerosol climatology from models, ground-based network, and existing satellite products.
  - What to retrieve and what not? Trying to pushing the limits, while still maintaining good accuracy. Fine-mode AOD, surface reflectance?

# Paper published

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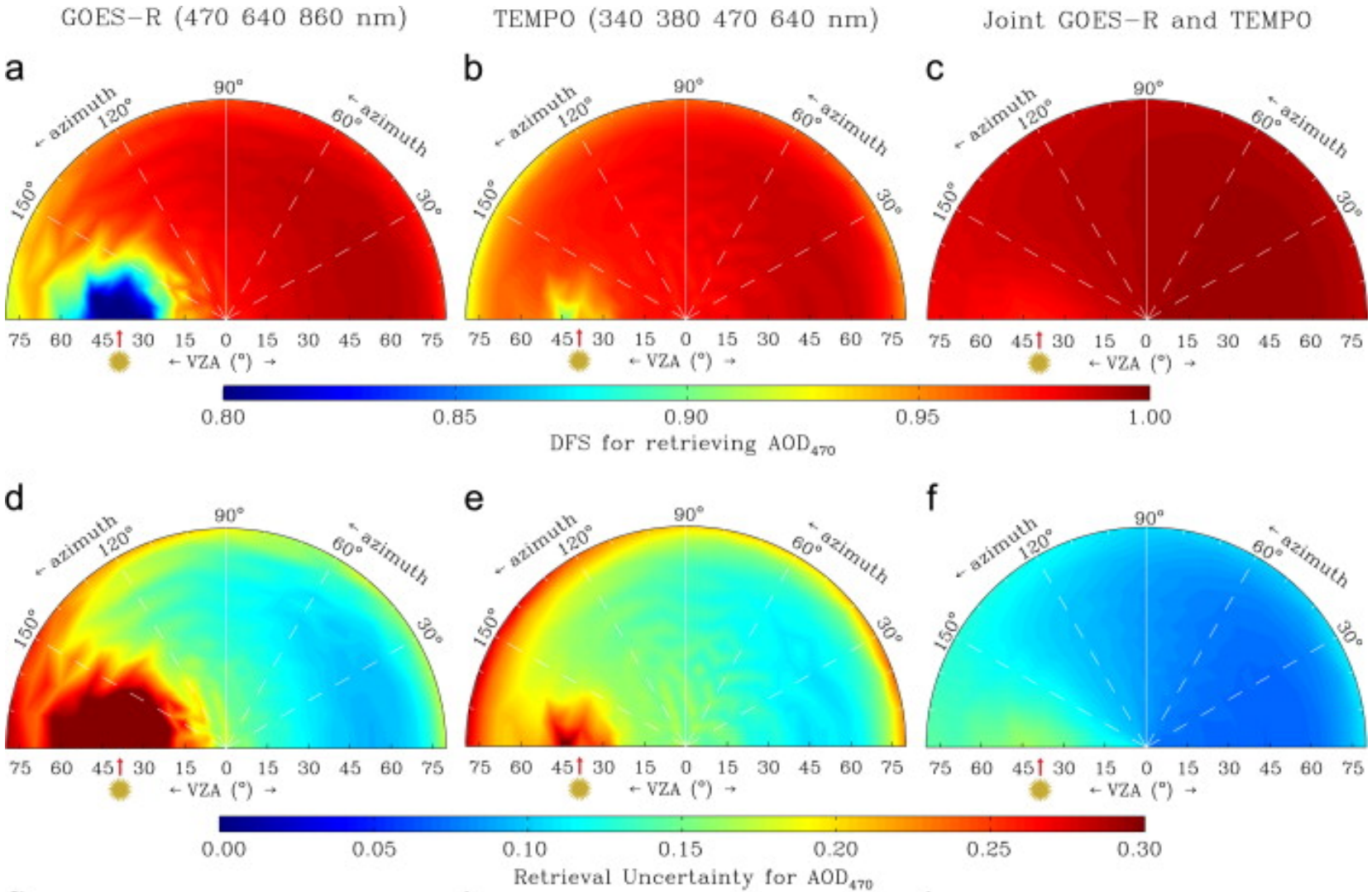
## A numerical testbed for remote sensing of aerosols, and its demonstration for evaluating retrieval synergy from a geostationary satellite constellation of GEO-CAPE and GOES-R

Jun Wang [a,*], Xiaoguang Xu [a], Shouguo Ding [a], Jing Zeng [a], Robert Spurr [b], Xiong Liu [c], Kelly Chance [c], Michael Mishchenko [d]

# Highlights

- A numerical testbed for remote sensing of aerosols for any satellite/ algorithm design.
- Linearly and coupled scattering and radiative transfer codes, optimization code included.
- Hyperspectral study of gas absorption effect on retrievals of aerosol height.
- Strong synergy between geo-satellites (GOES and TEMPO/GEO-CAPE) for aerosol retrieval.
- Polarization in O2 A band is sensitive to aerosol height over visibly bright surface.




**Joint retrieval reduces AOD and fine-mode AOD uncertainties respectively from 30% to 10% and from 40% to 20%.**

**The improvement of AOD is especially evident for cases when either TEMPO or GOES-R (but not both) are located close to the direction of the Sun (solar azimuth).**

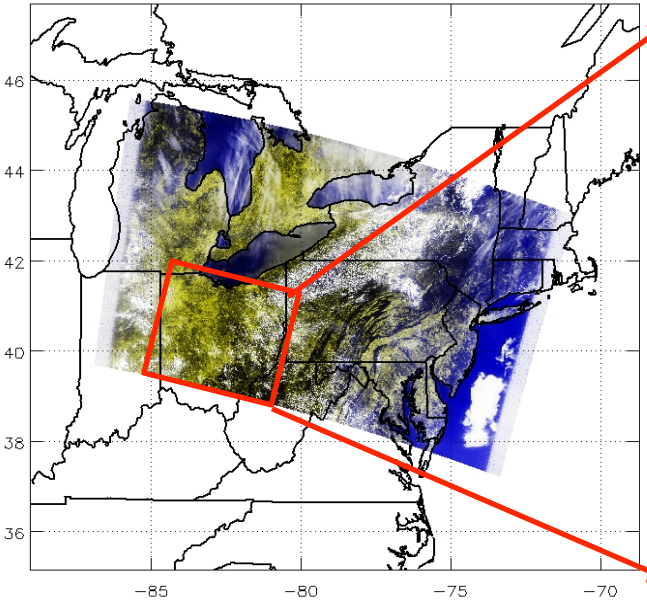
# BRDF at deep-blue and UV wavelengths, and its relationship with counterparts in NIR

- To apply MODIS-type algorithm, we need to link GOES-R NIR reflectance in one geometry with the TEMPO surface UV and blue reflectance in another geometry.
- Here we use CAI as a proxy for TEMPO and MODIS/VIIRS as a proxy for GOES-R.

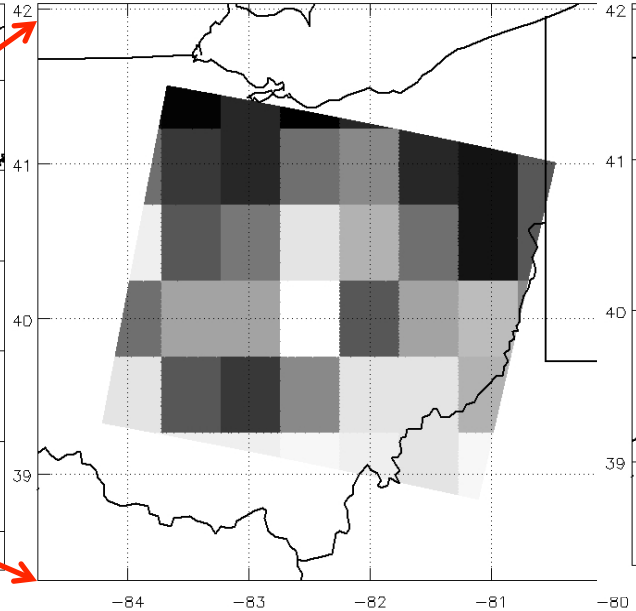
Cloud-Aerosol-Imager characteristics:

| BAND | RESOLUTION | SWATH |
|---|---|---|
| Band 1 (0.38μm), | 0.5 km | 1000 km |
| Band 2 (0.67μm), | 0.5 km | 1000 km |
| Band 3 (0.87μm), | 0.5 km | 1000 km |
| Band 4 (1.6μm), | 1.5 km | 750 km |

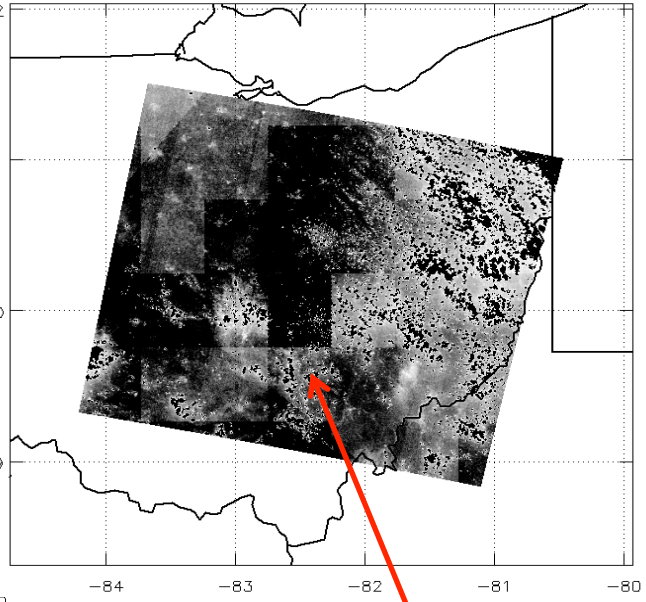
# Retrieval of AOD from CAI 380 nm




**OMI LER 380 nm**



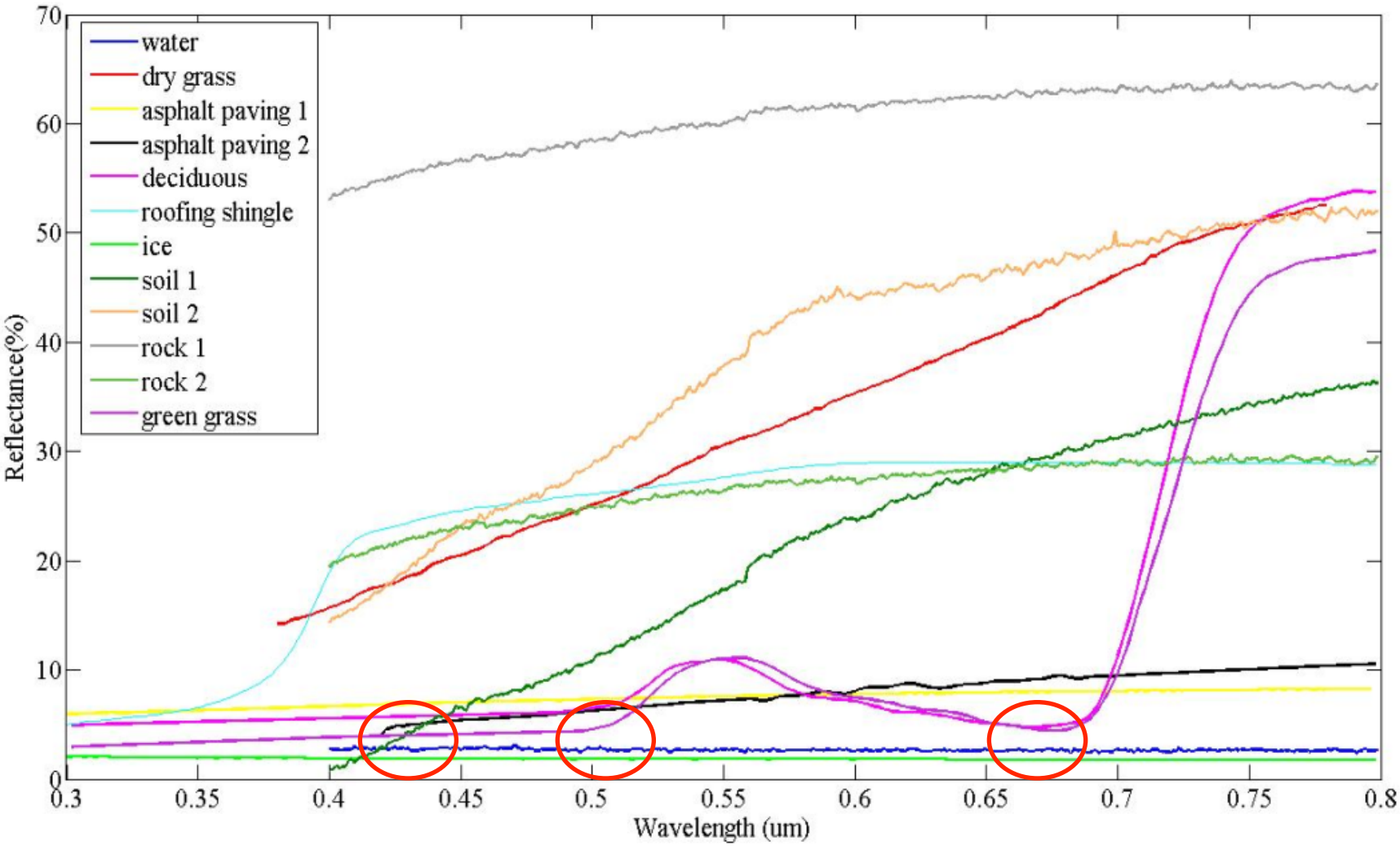

**CAI AOD @ 380 nm**




**OMI LER resolution is too coarse (0.5° X 0.5°) to be used for AOD retrieval from CAI (0.5 m X 0.5 m) .**

**patches due to surface reflectance database.**

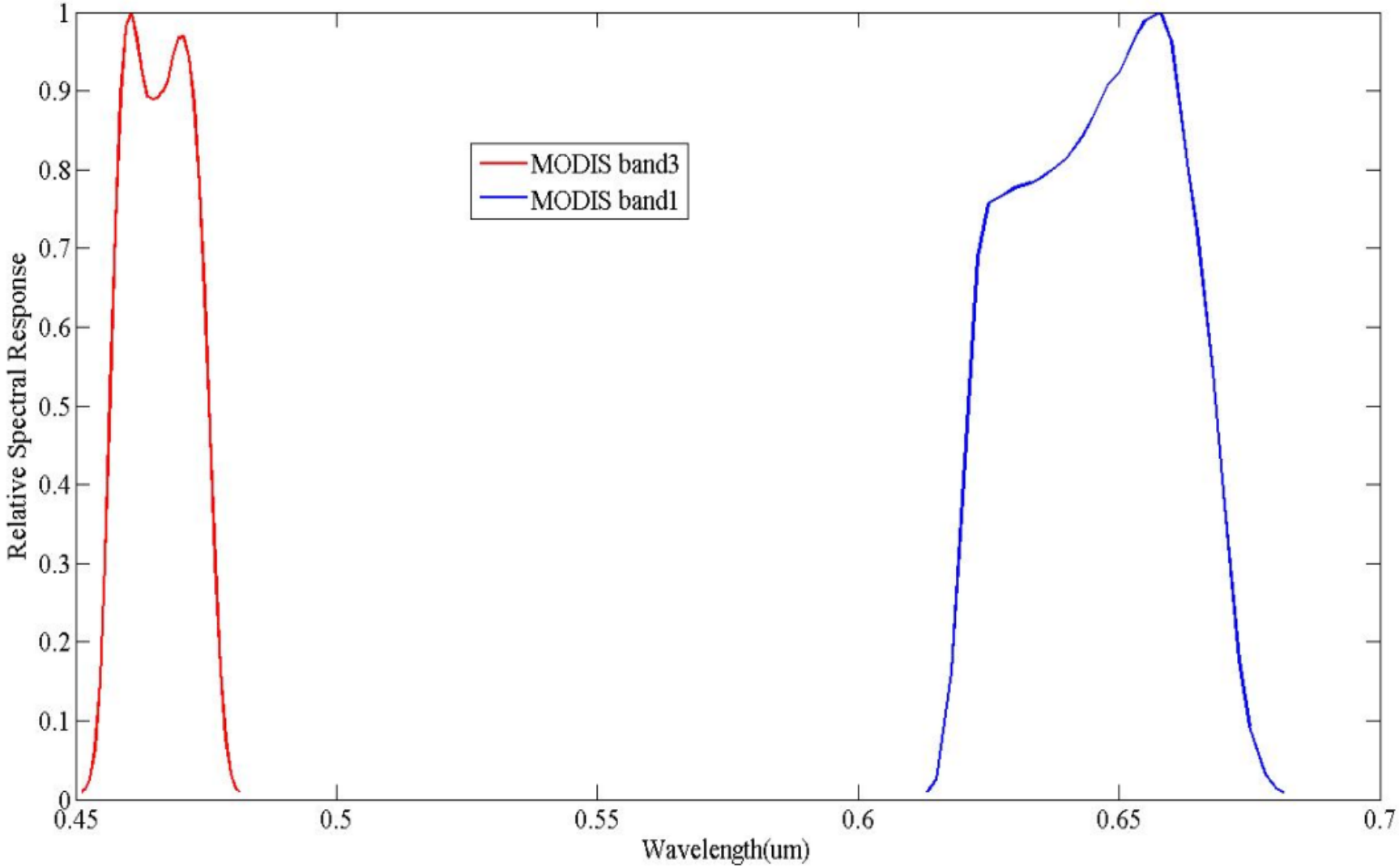
# Can we extrapolate the UV reflectance from MODIS channels?




**For MODIS, wavelength(nm) of reflectance is**

**645 555 469 555 1240 1640 2130**

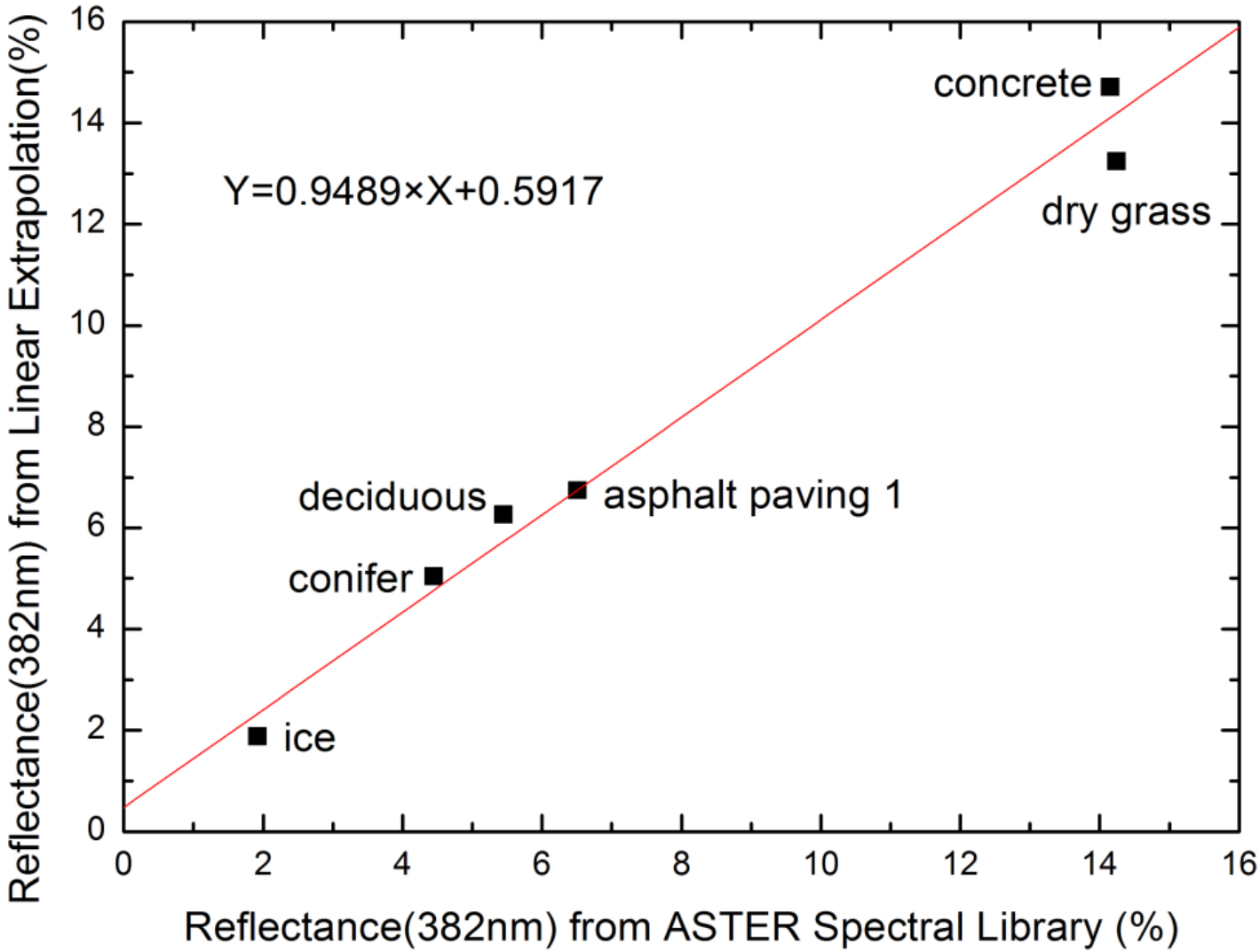
# MODIS Spectral Response Function




**For MODIS, wavelength(nm) of reflectance is**

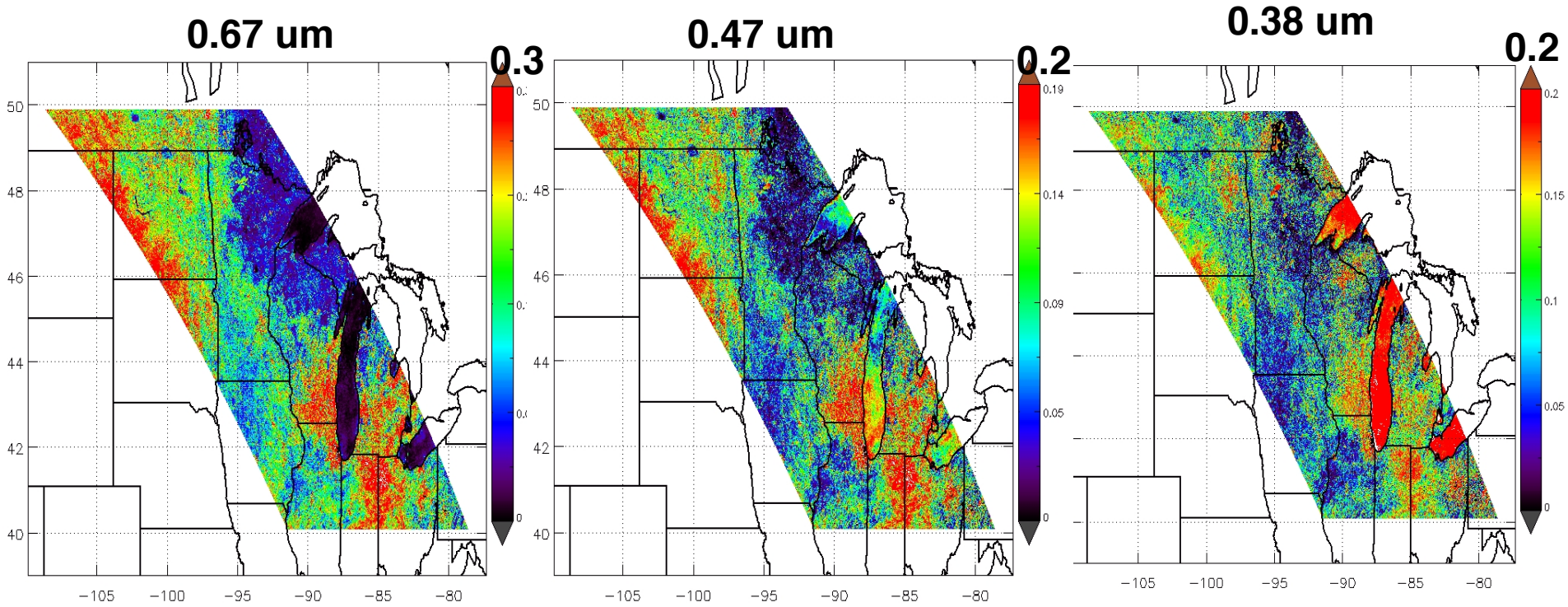
**645 555 469 555 1240 1640 2130**

# Extrapolation appears to be good for most surface types except roofing shingles .

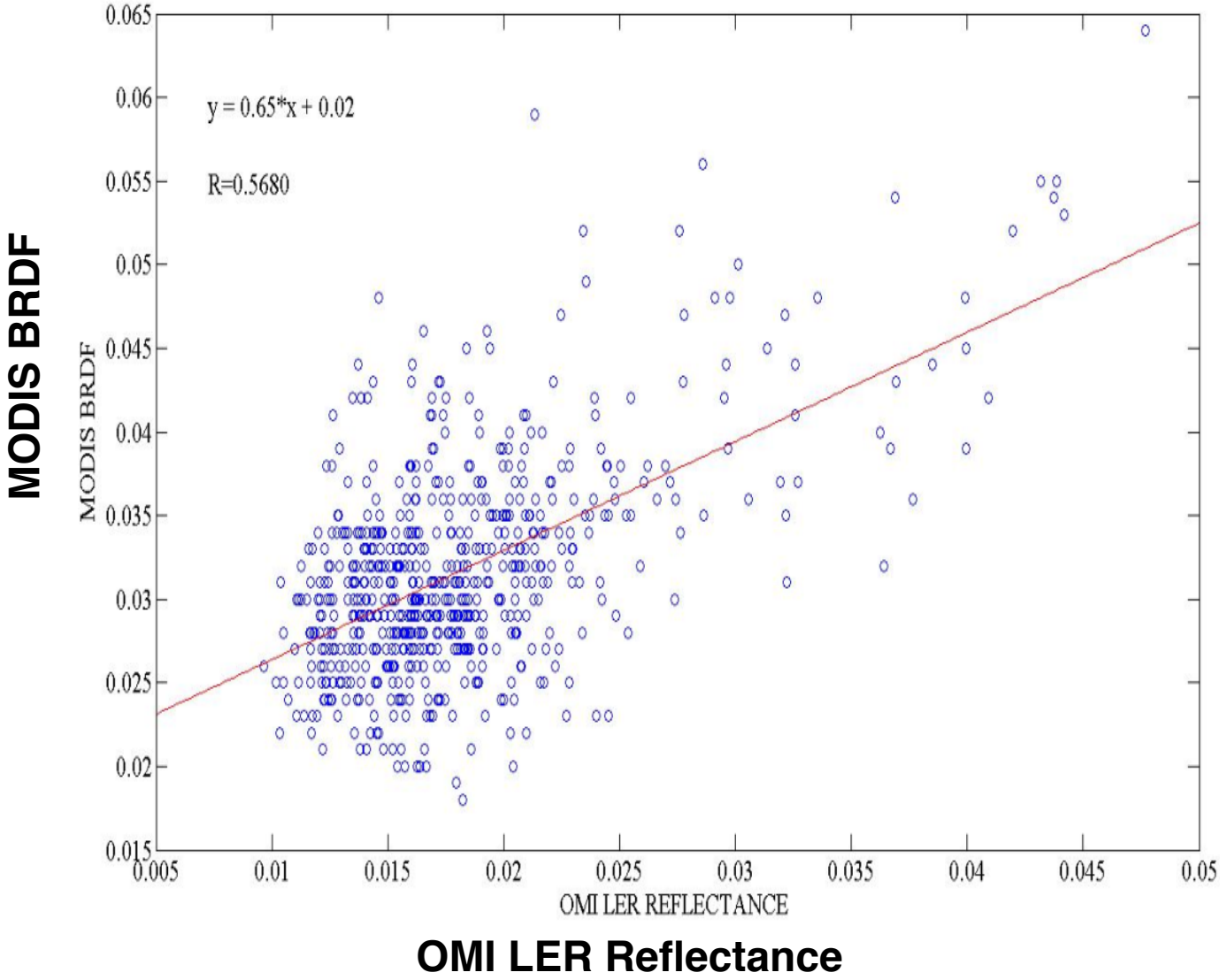


# First Trial

**SZA=30, VZA=0, $SR^{-1}$**

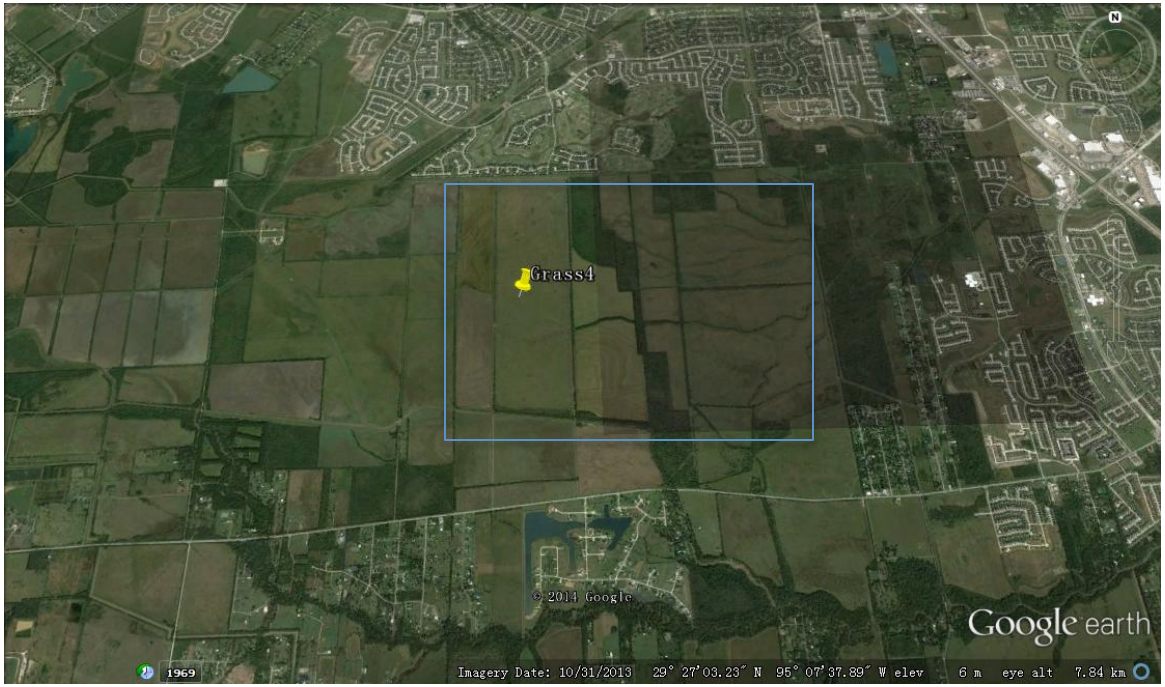


# Comparison with OMI

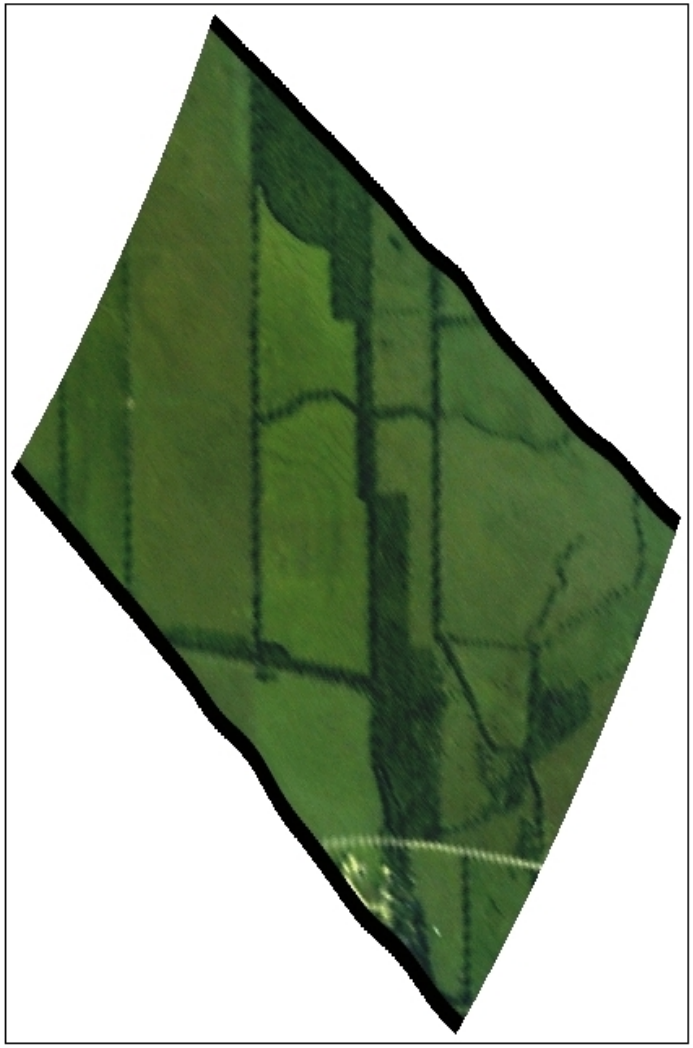


# Geo-TASO work

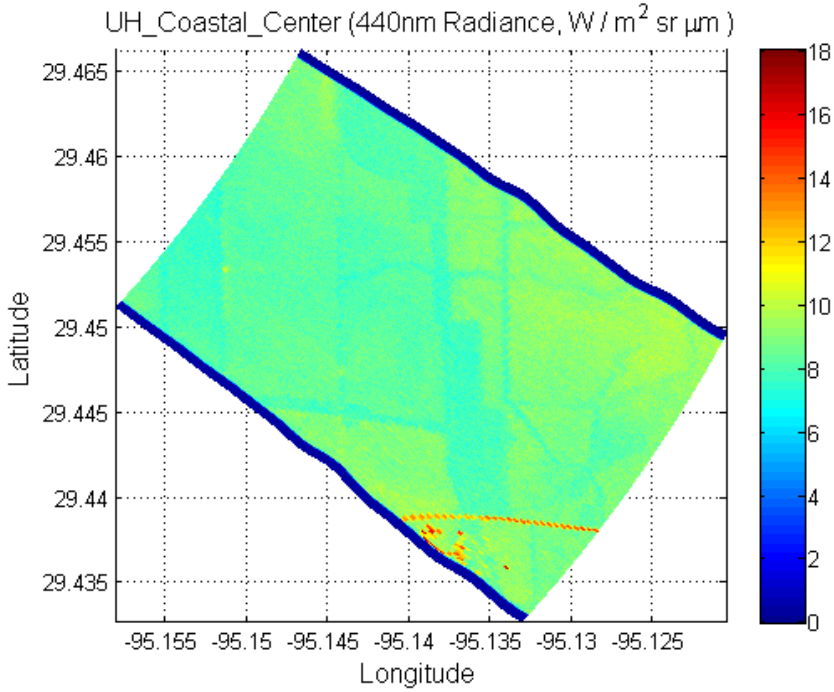
with James Leitch and Ball team

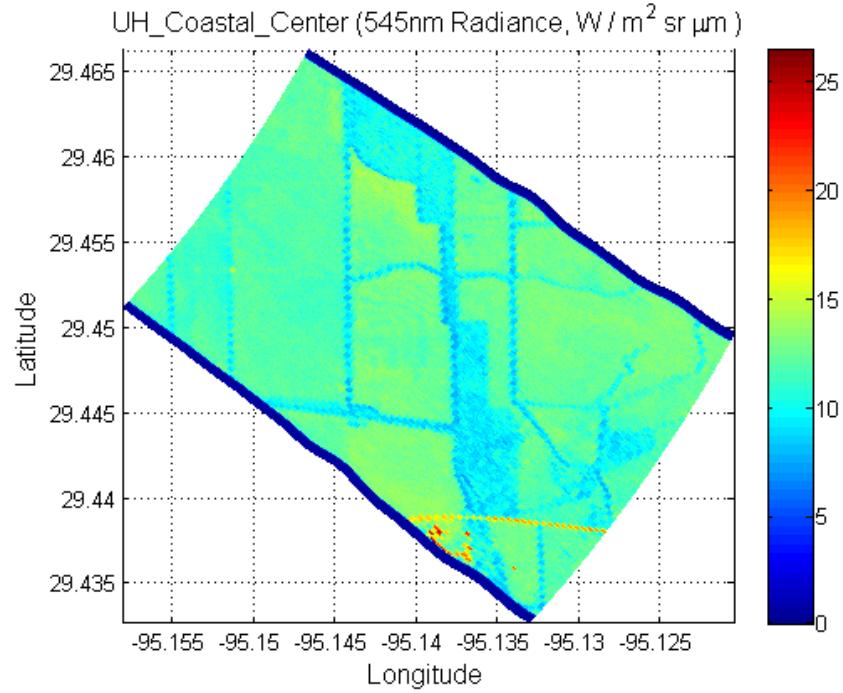


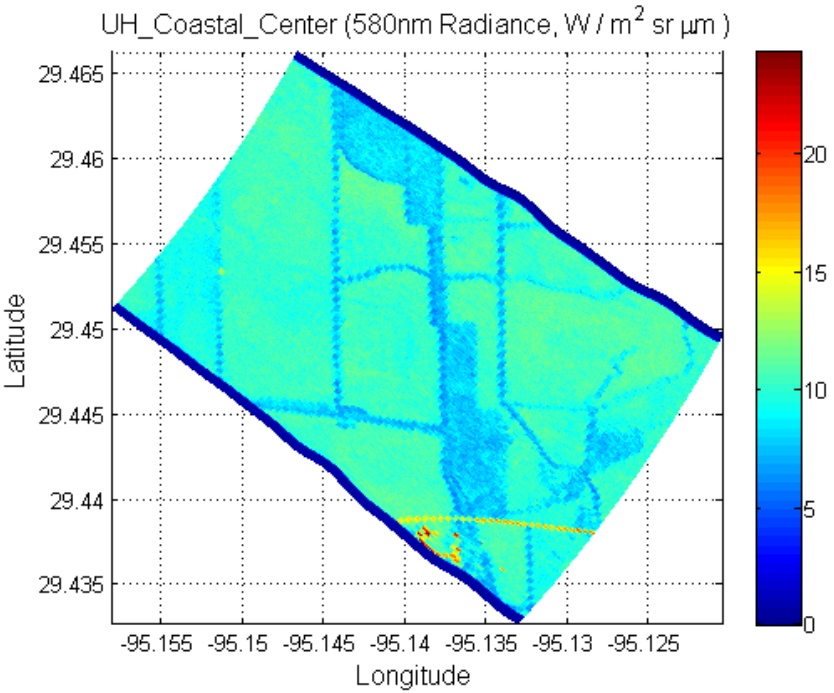

Google earth

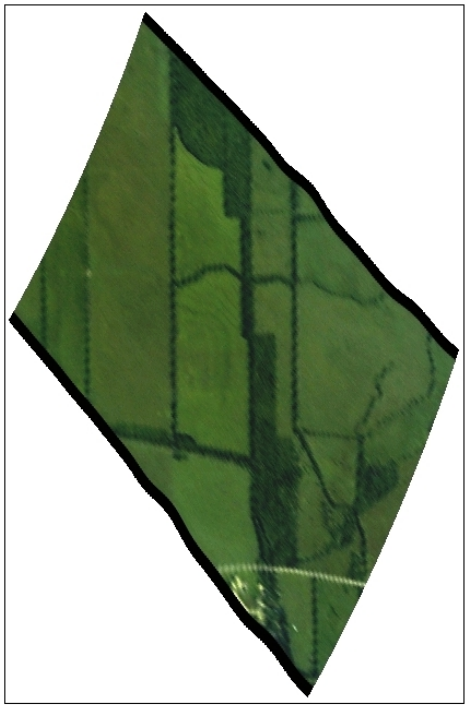


Geo-TASO RGB

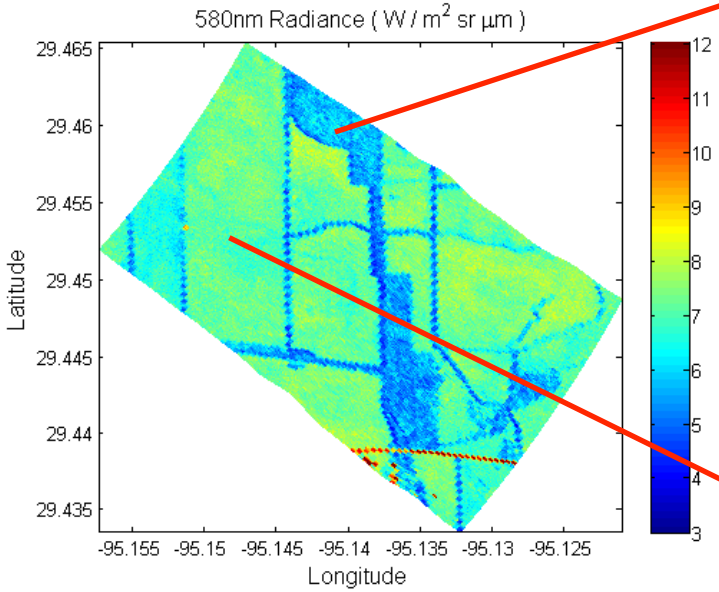

UH_Coastal_Center (440nm Radiance, W / m2 sr µm )
Latitude
Longitude
29.465
29.46
29.455
29.45
29.445
29.44
29.435
-95.155
-95.15
-95.145
-95.14
-95.135
-95.13
-95.125
18
16
14
12
10
8
6
4
2
0

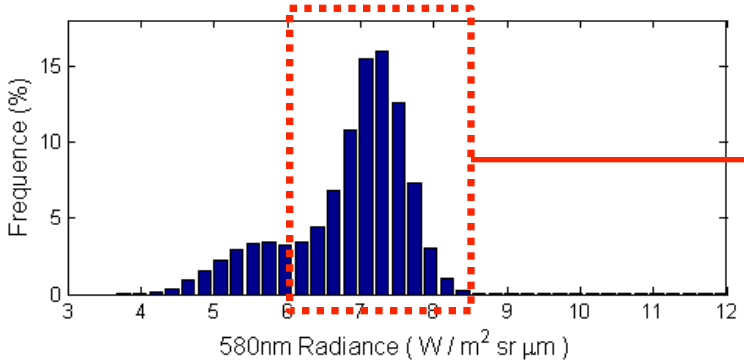

UH_Coastal_Center (545nm Radiance, W / m2 sr µm )
Latitude
Longitude
29.465
29.46
29.455
29.45
29.445
29.44
29.435
-95.155
-95.15
-95.145
-95.14
-95.135
-95.13
-95.125
25
20
15
10
5
0

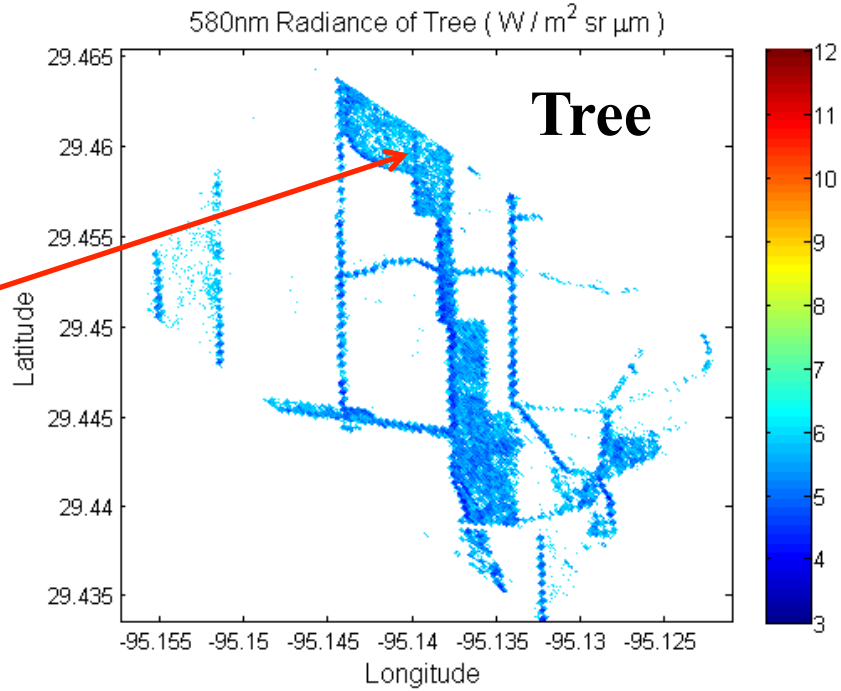

UH_Coastal_Center (580nm Radiance, W / m2 sr µm )
Latitude
Longitude
29.465
29.46
29.455
29.45
29.445
29.44
29.435
-95.155
-95.15
-95.145
-95.14
-95.135
-95.13
-95.125
20
15
10
5
0

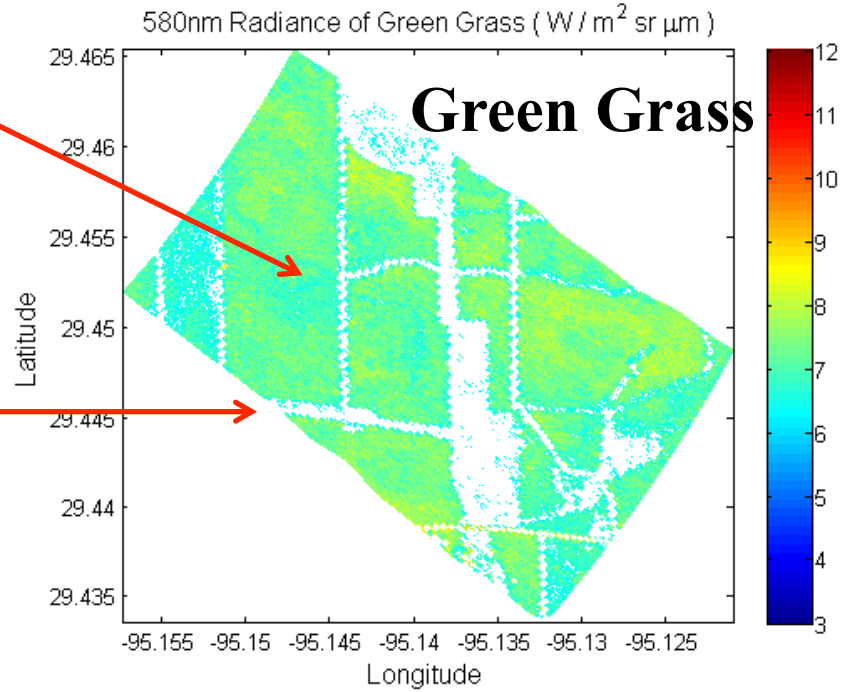


# Tree & Green Grass

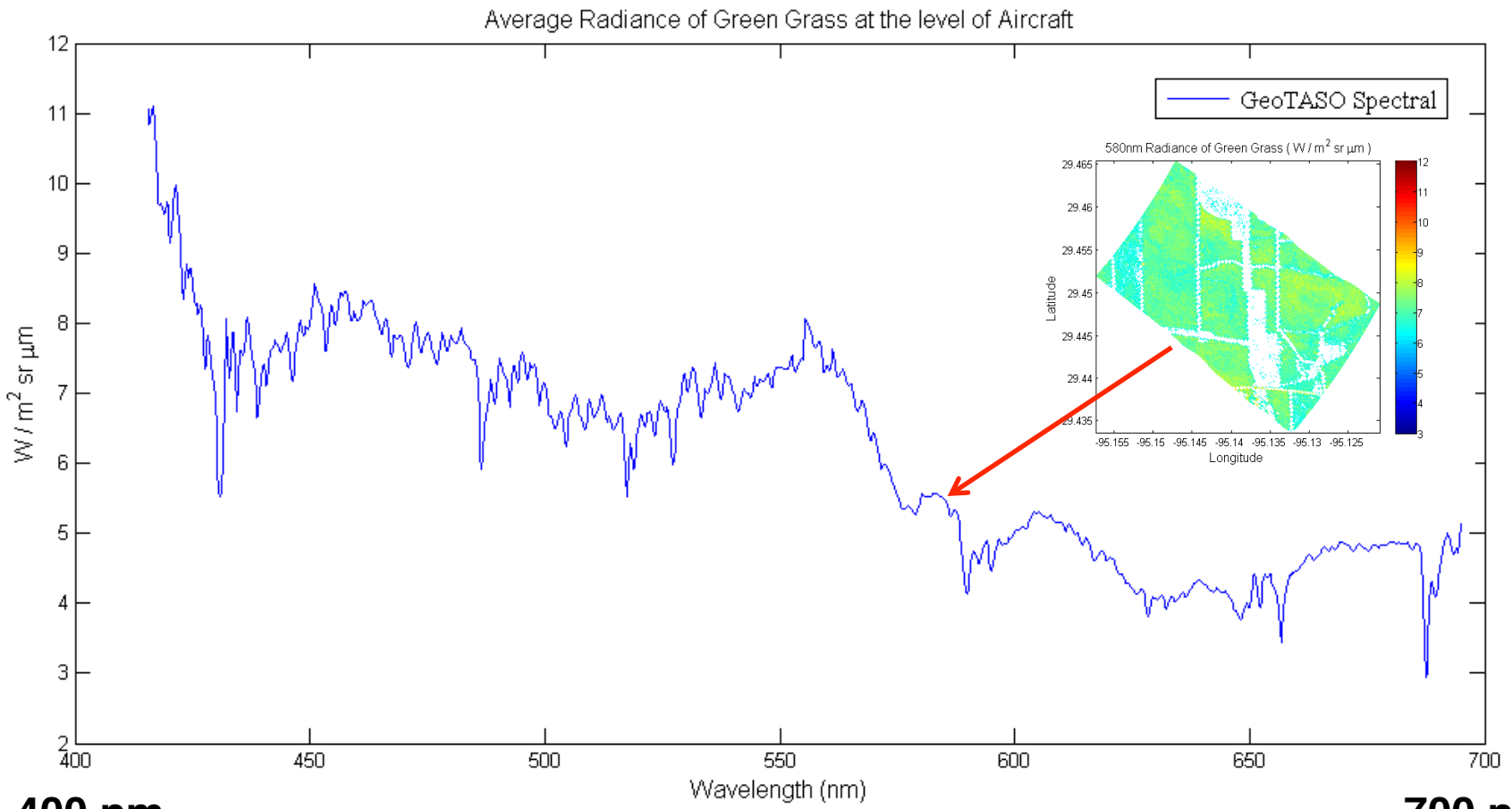


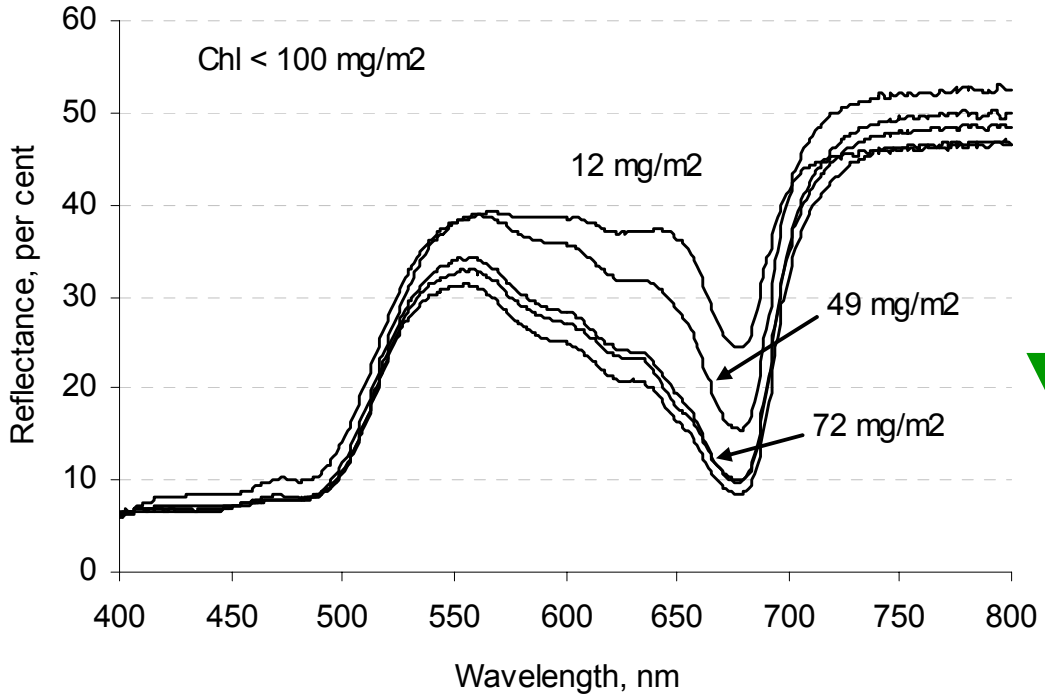



# Geo-TASO measurements over grass

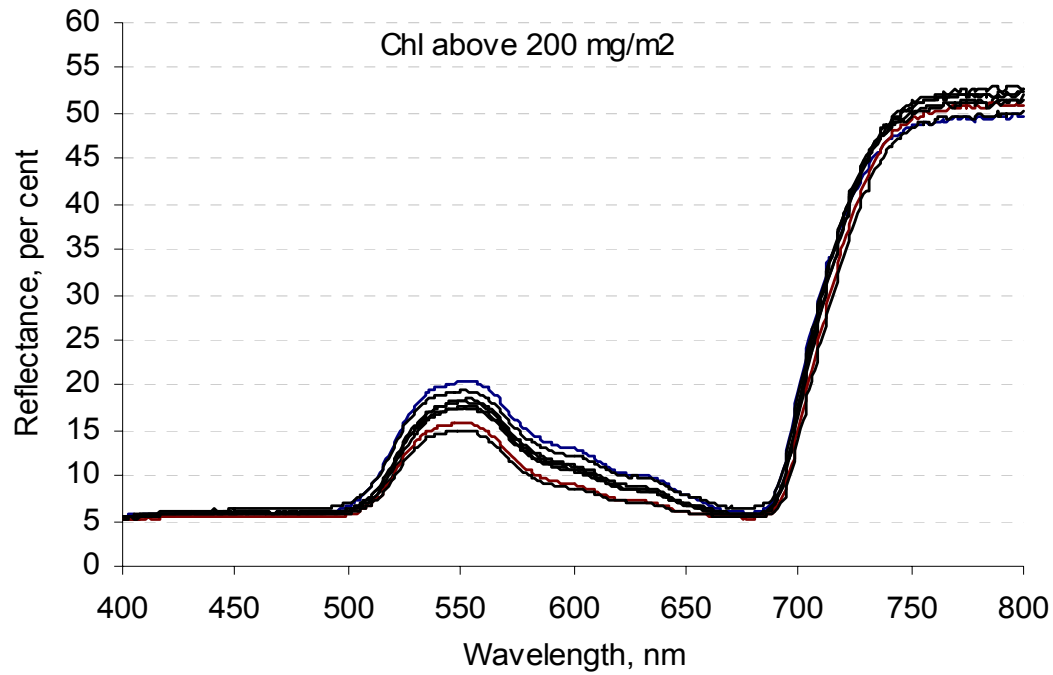


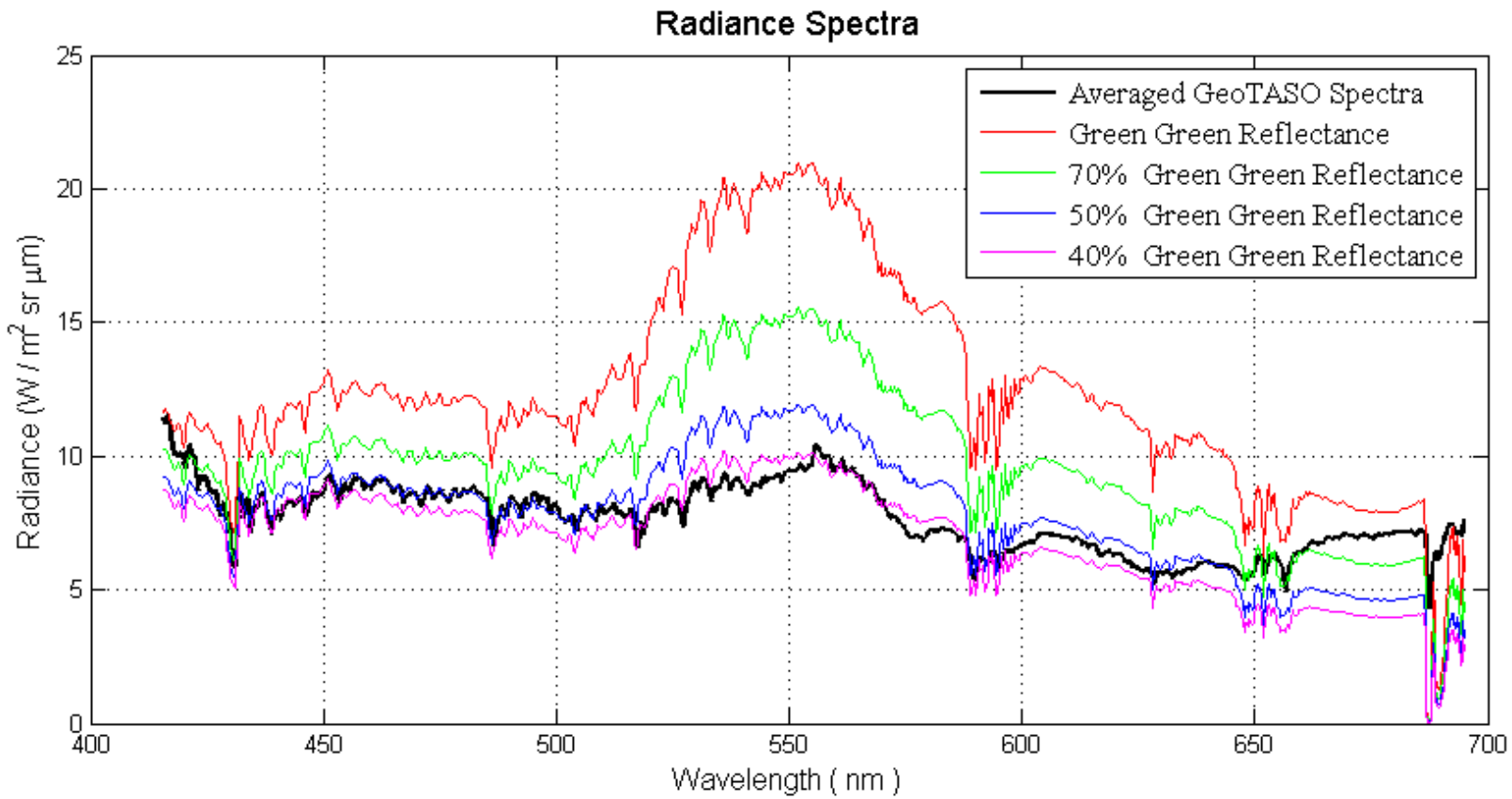

**400 nm** **550 nm** **700 nm**

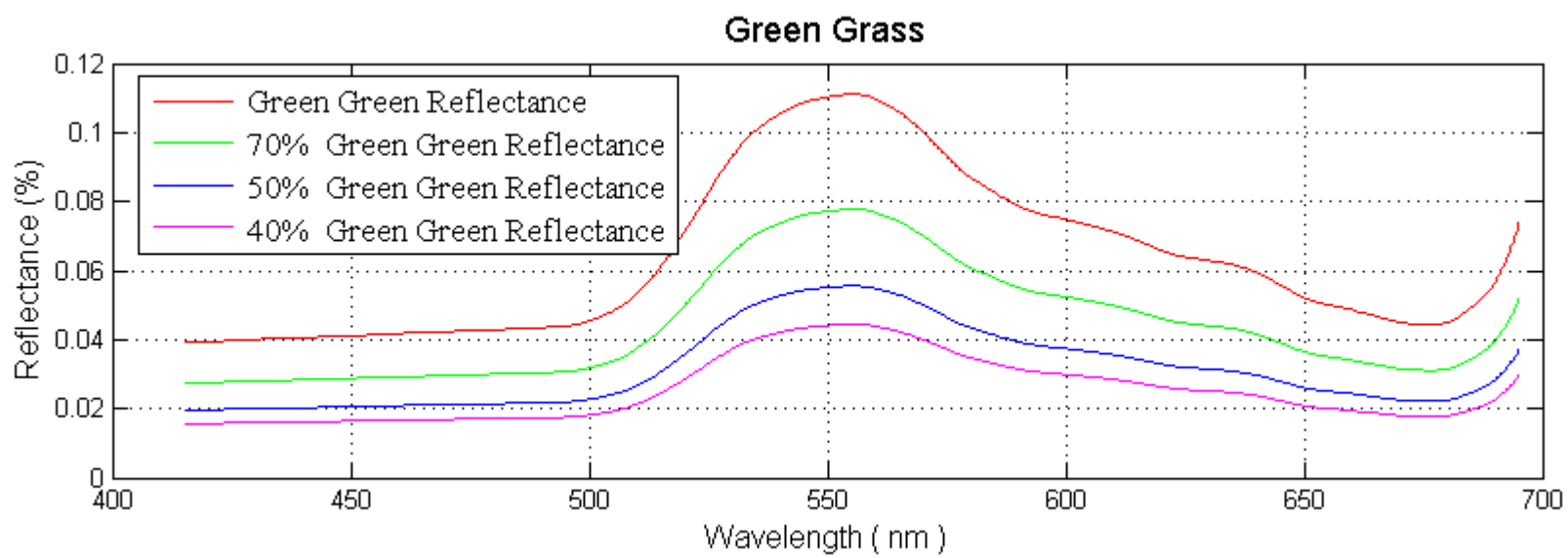


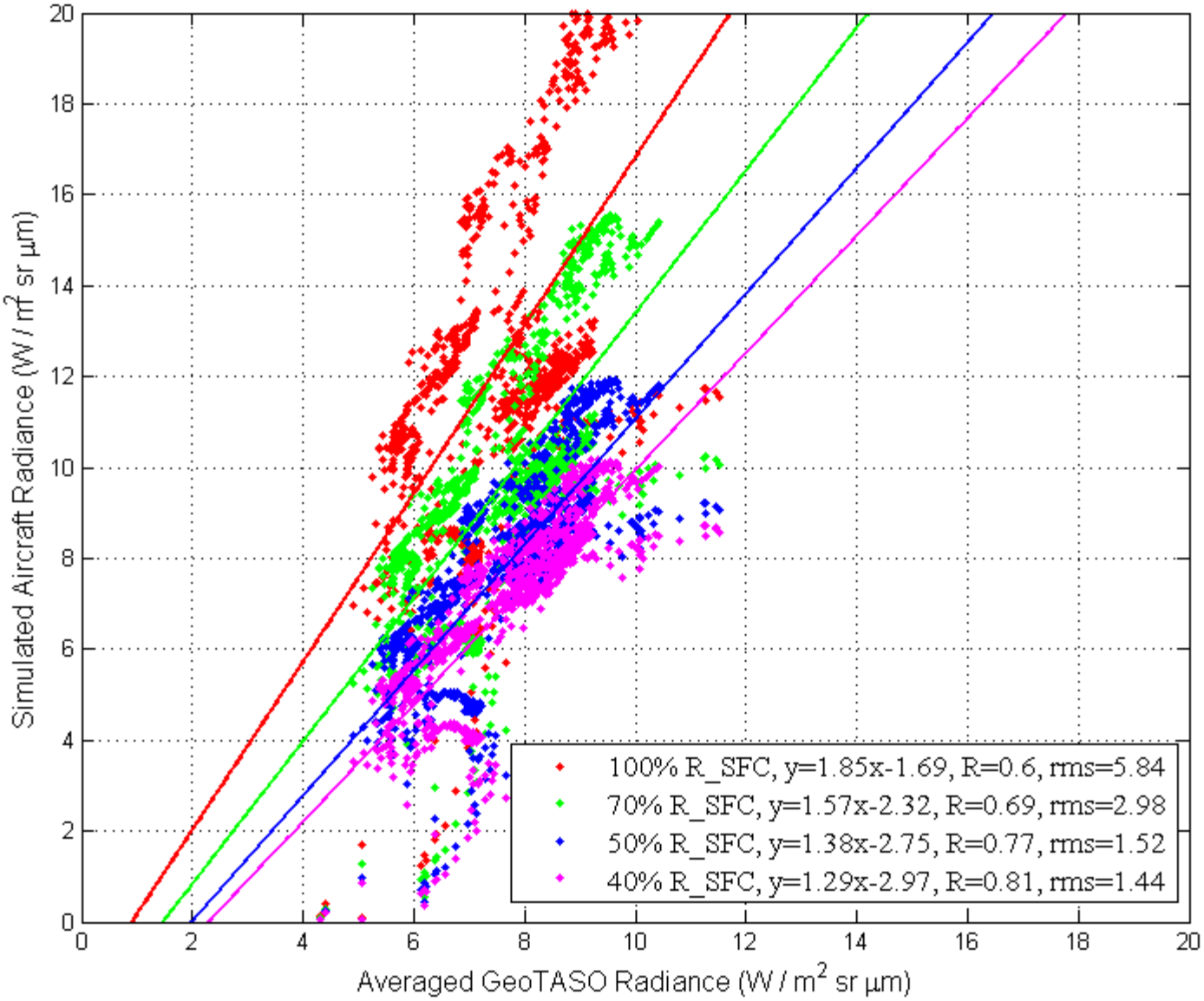

Chl

**The reflectance in green band highly depends on Chlorophyll.**




Radiance Spectra
Averaged GeoTASO Spectra
Green Green Reflectance
70% Green Green Reflectance
50% Green Green Reflectance
40% Green Green Reflectance
Radiance (W / m2 sr µm)
Wavelength ( nm )
0
5
10
15
20
25
400
450
500
550
600
650
700


Green Grass
Green Green Reflectance
70% Green Green Reflectance
50% Green Green Reflectance
40% Green Green Reflectance
Reflectance (%)
Wavelength ( nm )
0
0.02
0.04
0.06
0.08
0.1
0.12
400
450
500
550
600
650
700


Simulated Aircraft Radiance (W / m2 sr µm)
Averaged GeoTASO Radiance (W / m2 sr µm)
0
2
4
6
8
10
12
14
16
18
20
100% R_SFC, y=1.85x-1.69, R=0.6, rms=5.84
70% R_SFC, y=1.57x-2.32, R=0.69, rms=2.98
50% R_SFC, y=1.38x-2.75, R=0.77, rms=1.52
40% R_SFC, y=1.29x-2.97, R=0.81, rms=1.44

# Summary

- Deriving high-resolution UV surface BRDF and their link to visible spectrum – in progress
- Retrieving AOD with high-resolution UV data – in progress
- Geo-TASO work – in progress

**Thank you.**