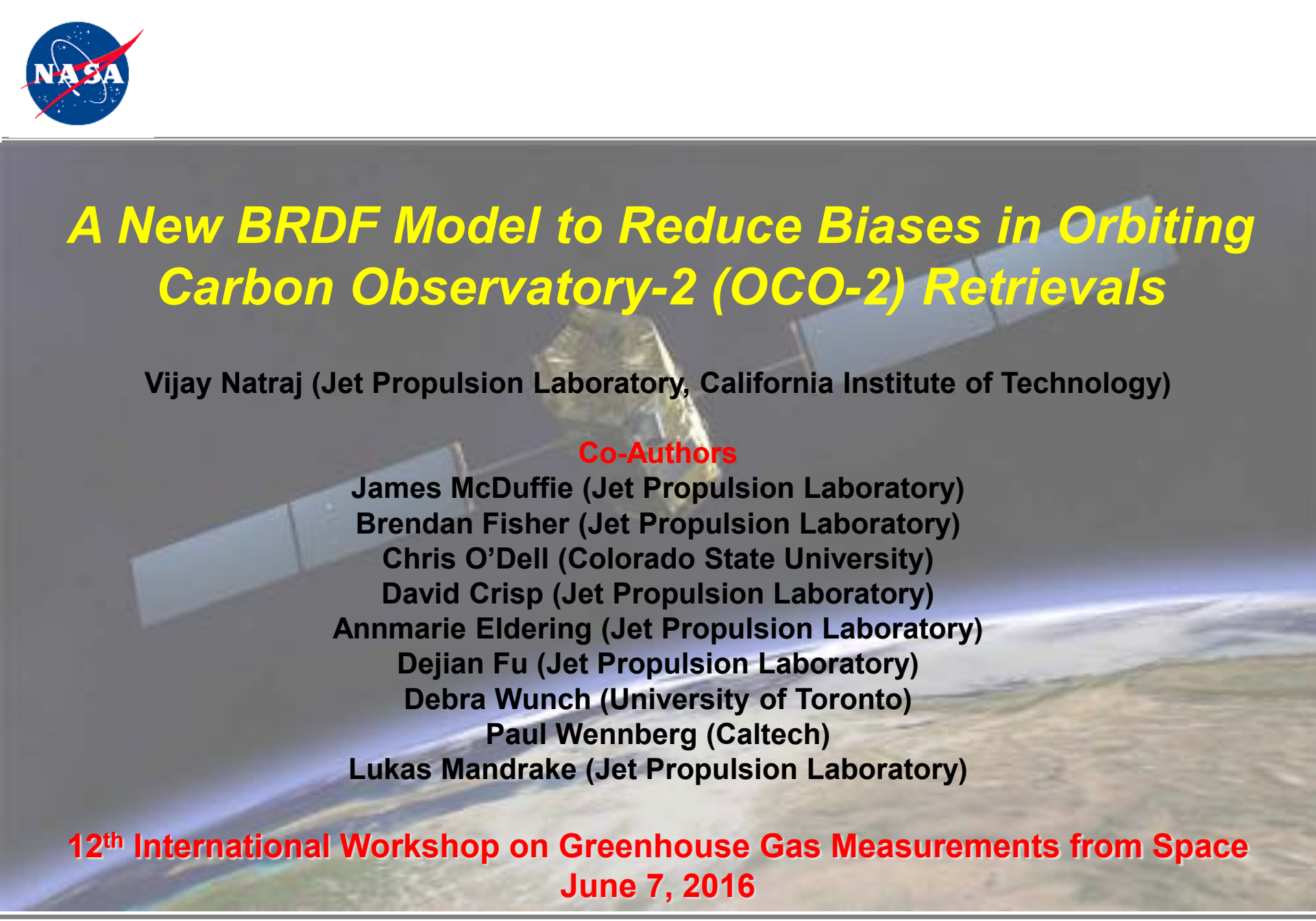

A New BRDF Model to Reduce Biases in Orbiting Carbon Observatory-2 (OCO-2) Retrievals

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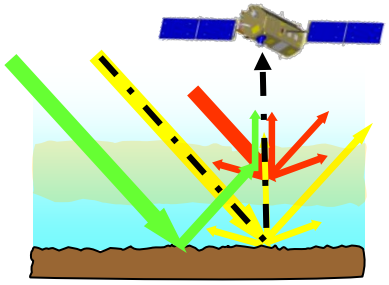
12th International Workshop on Greenhouse Gas Measurements from Space
June 7, 2016

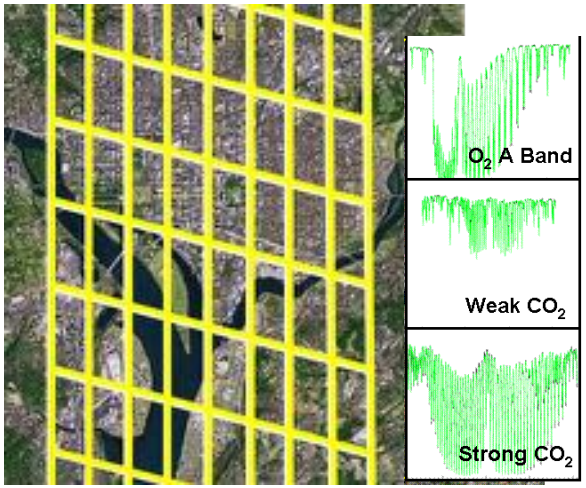
OCO-2 Science Viewing Modes

Nadir Observations:

+ Small footprint (< 3 km²)

– Low Signal/Noise over dark surfaces (ocean, ice)

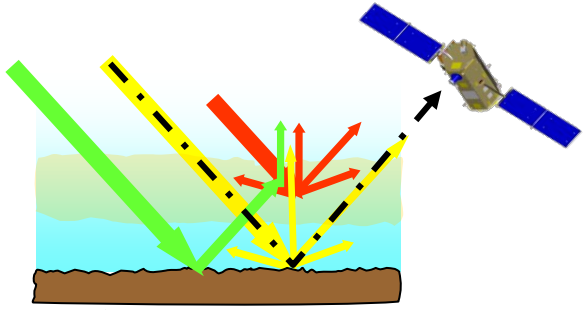


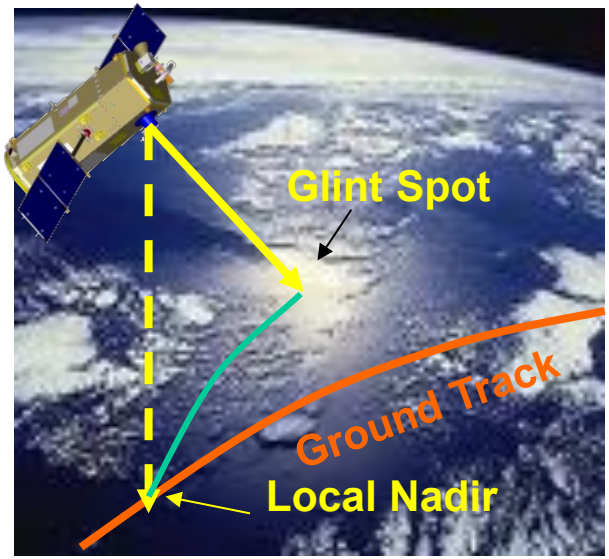


Glint Observations:

+ Improves Signal/Noise over oceans

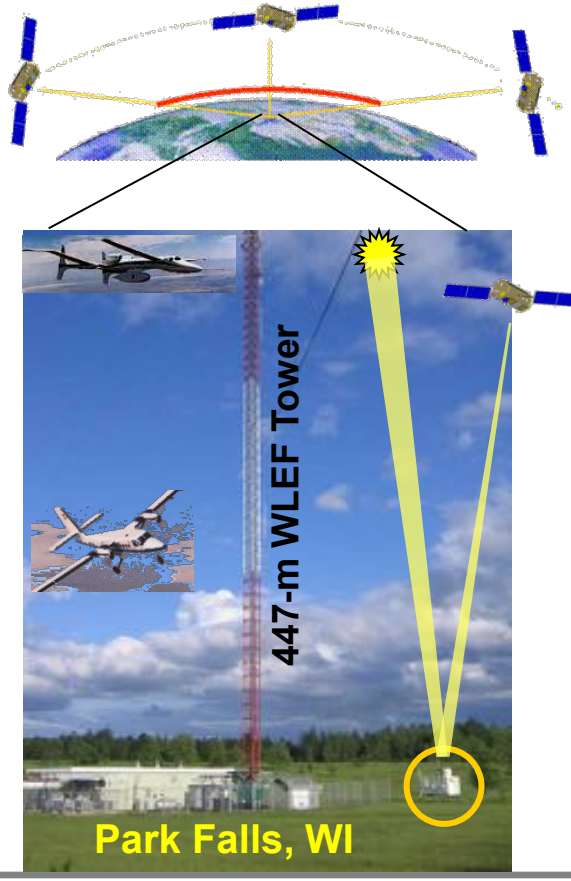
– More cloud interference



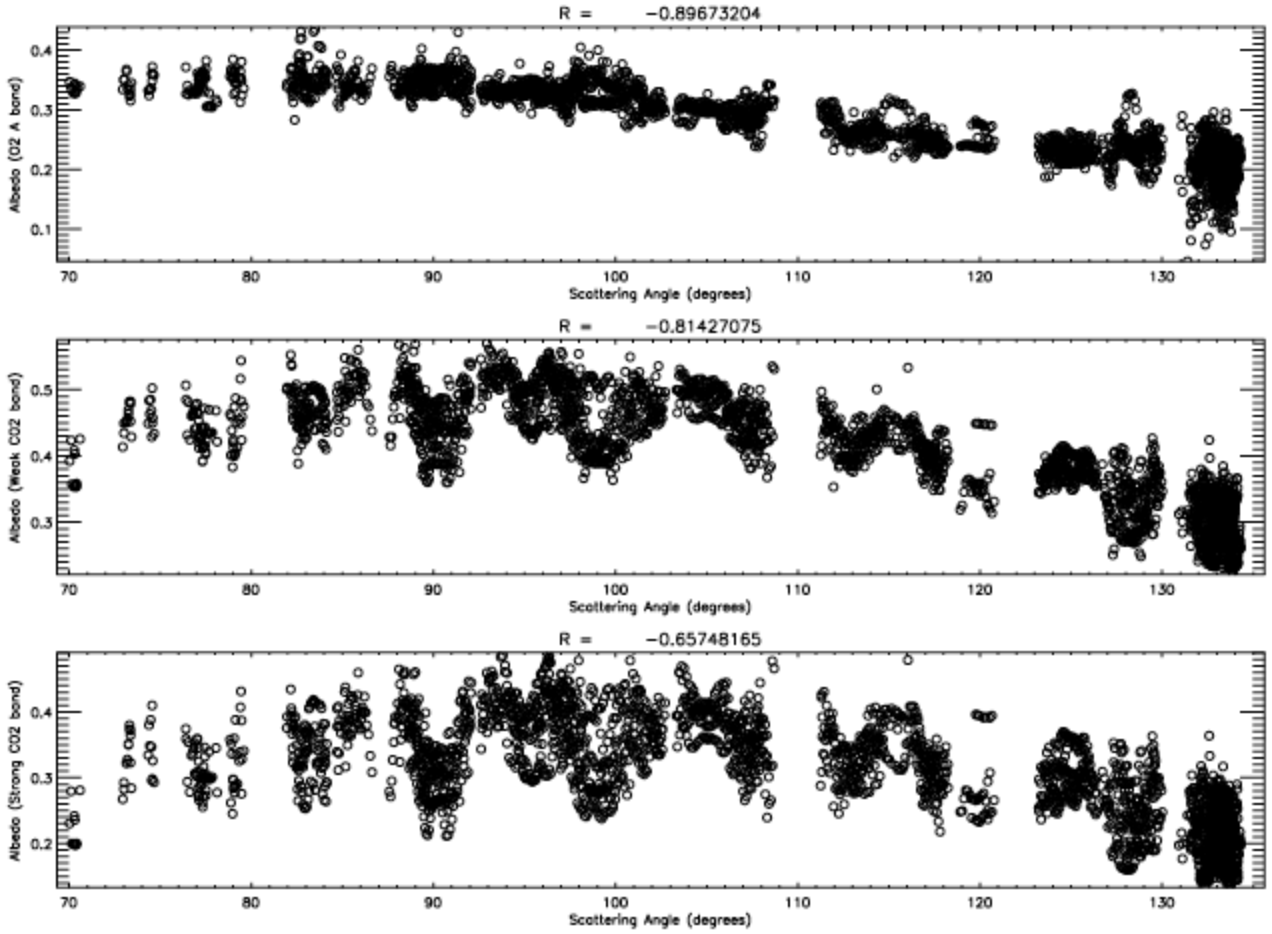


Target Observations:

- Validation over ground based FTS sites, field campaigns, other targets



Retrieved Albedo Correlated With Scattering Angle



Retrieved albedo correlated with scattering angle => BRDF effects?

BRDF Formulation

$$BRDF(\lambda) = \left[w + s(\lambda - \lambda_0)\right] F(p_1, p_2)$$

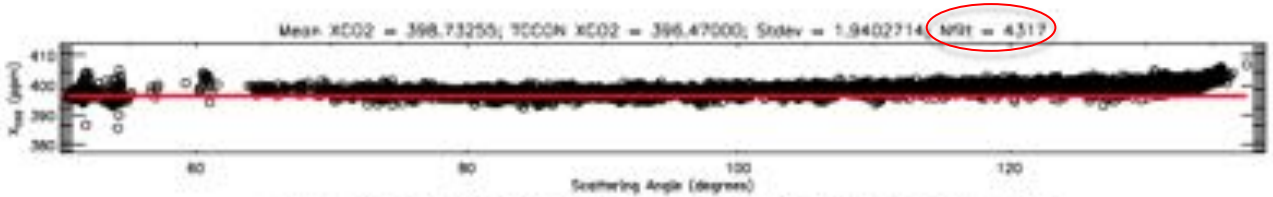
- w: overall BRDF amplitude
- s: slope of BRDF amplitude
- λ: wavelength
- λ_0: central wavelength (where parameters are retrieved)
- F: function describing BRDF shape
- F has slightly different forms for bare soil and vegetated surfaces
- BRDF kernel reduces to Lambertian kernel for certain choice of F
- p_1 and/or p_2 can be retrieved or held fixed

Target Mode Tests

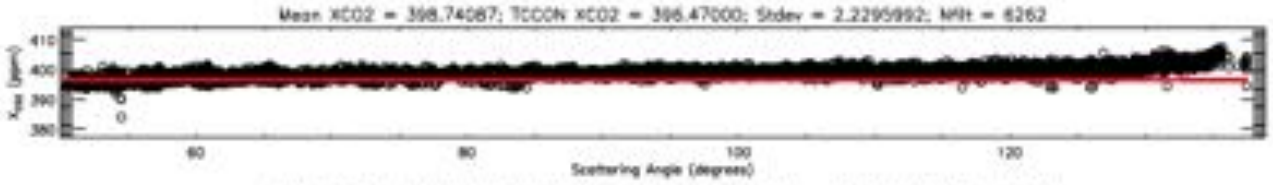
Retrieved XCO2

Number of filtered, converged scenes

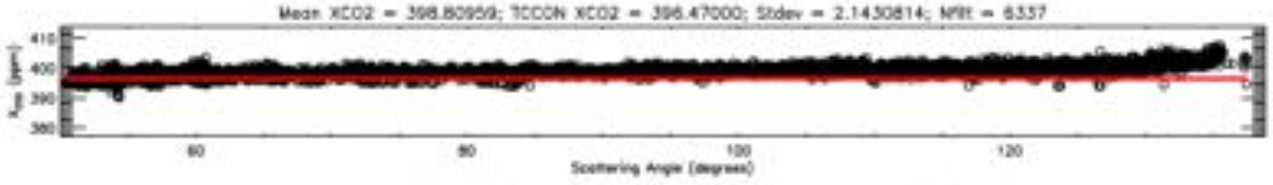
Lambertian



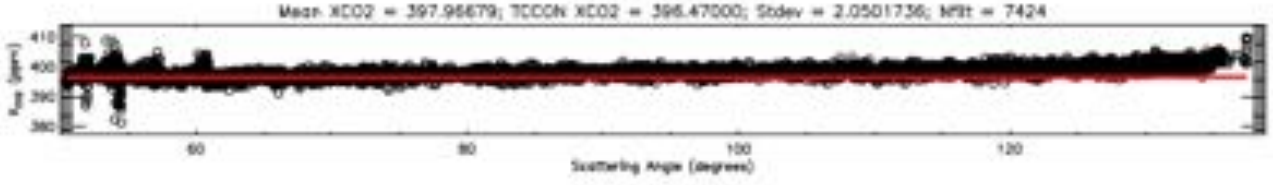
Soil BRDF, p_1, p_2 retrieved



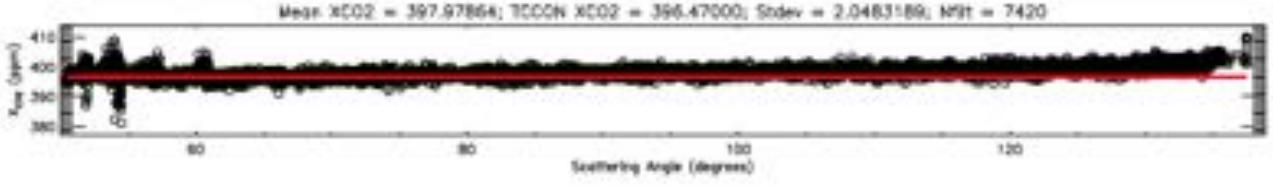
Veg BRDF, p_1, p_2 retrieved



Soil BRDF, p_1, p_2 not retrieved



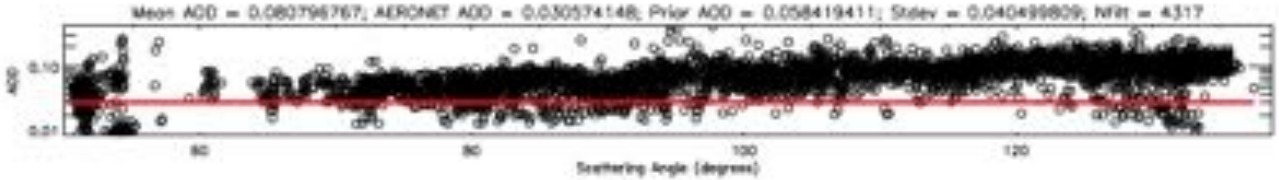
Veg BRDF, p_1, p_2 not retrieved



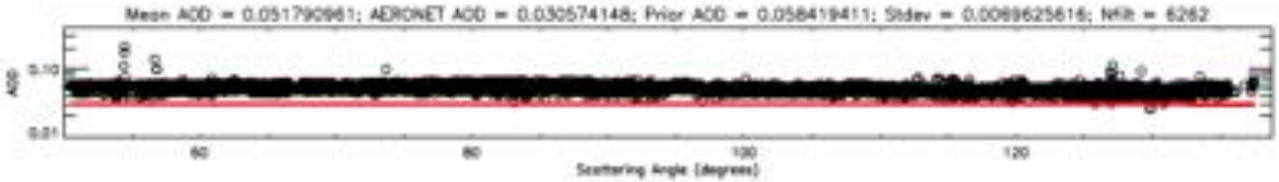
X_{CO2} closer to TCCON value for BRDF models, especially when BRDF shape is fixed

Retrieved AOD

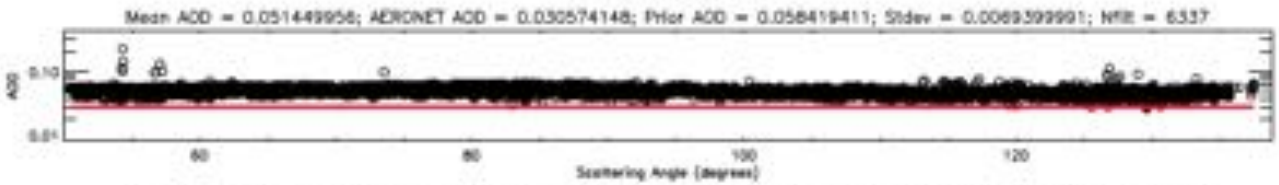
Lambertian



Soil BRDF, p_1, p_2 retrieved

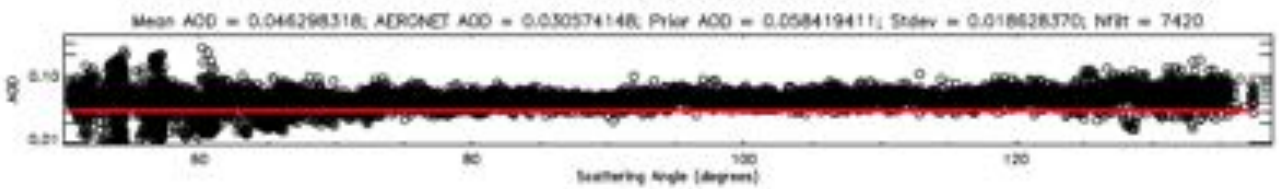


Veg BRDF, p_1, p_2 retrieved



Soil BRDF, p_1, p_2 not retrieved

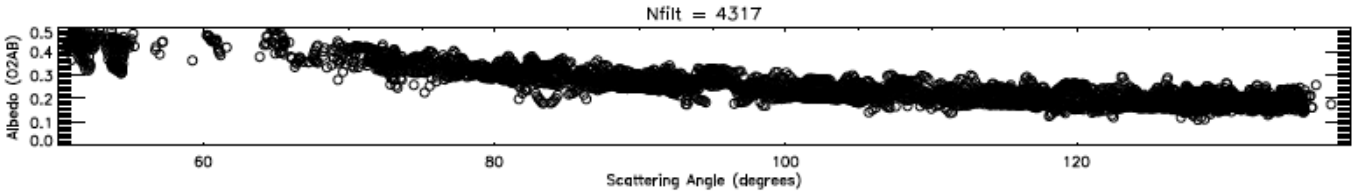
Veg BRDF, p_1, p_2 not retrieved



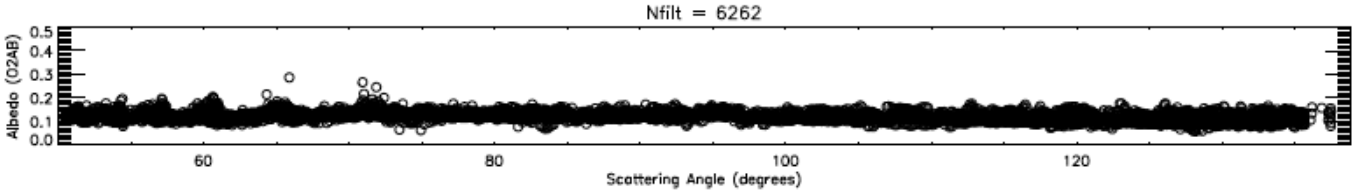
AOD closer to AERONET value, and uncorrelated with scattering angle, for BRDF models

Retrieved Albedo

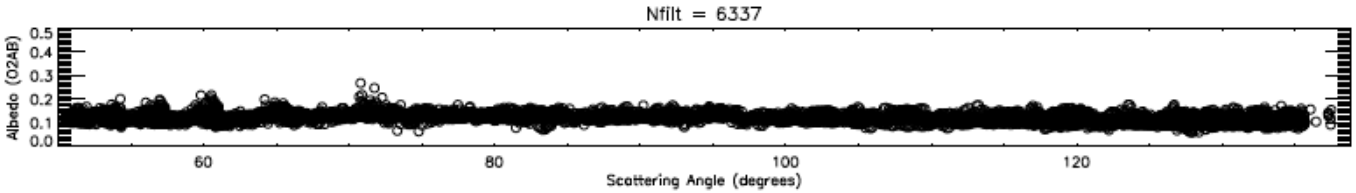
Lambertian



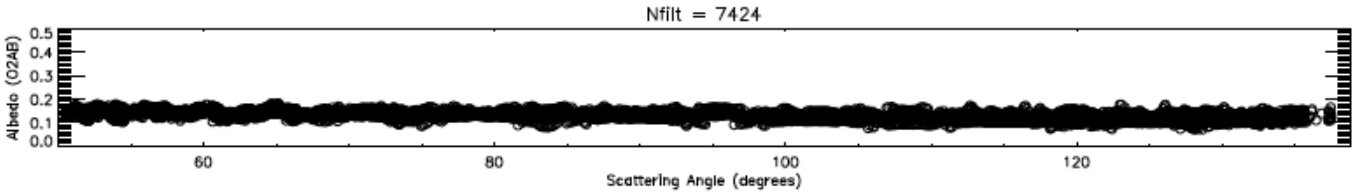
Soil BRDF, p_1, p_2 retrieved



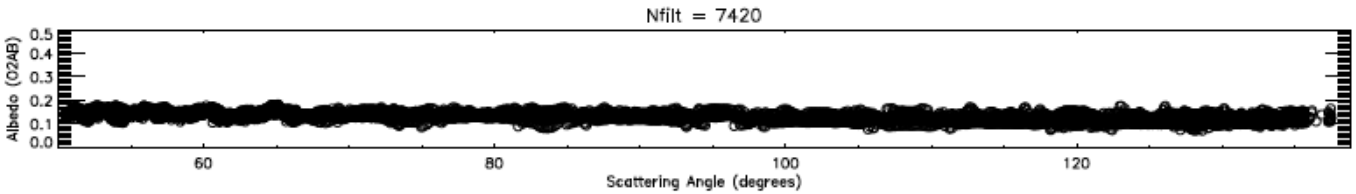
Veg BRDF, p_1, p_2 retrieved



Soil BRDF, p_1, p_2 not retrieved



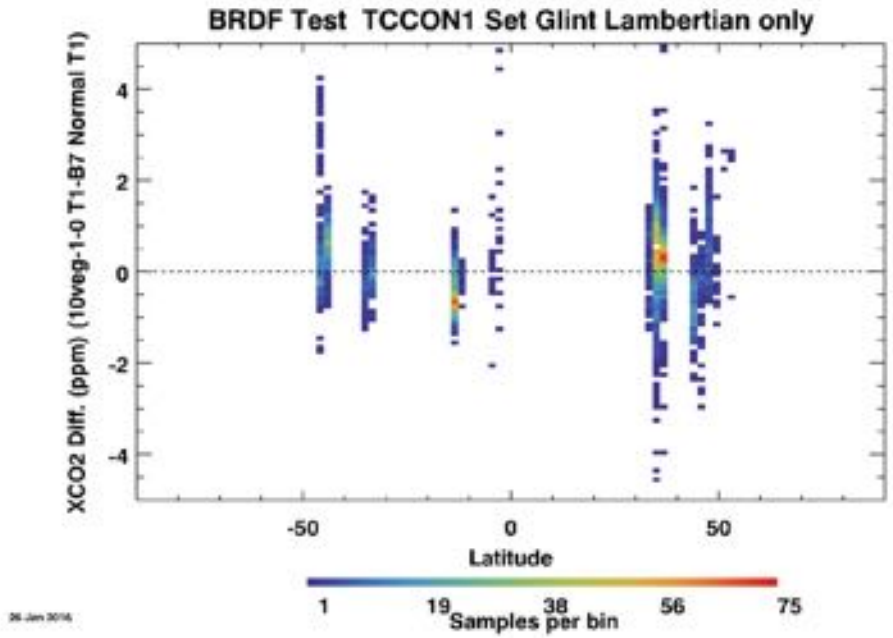
Veg BRDF, p_1, p_2 not retrieved

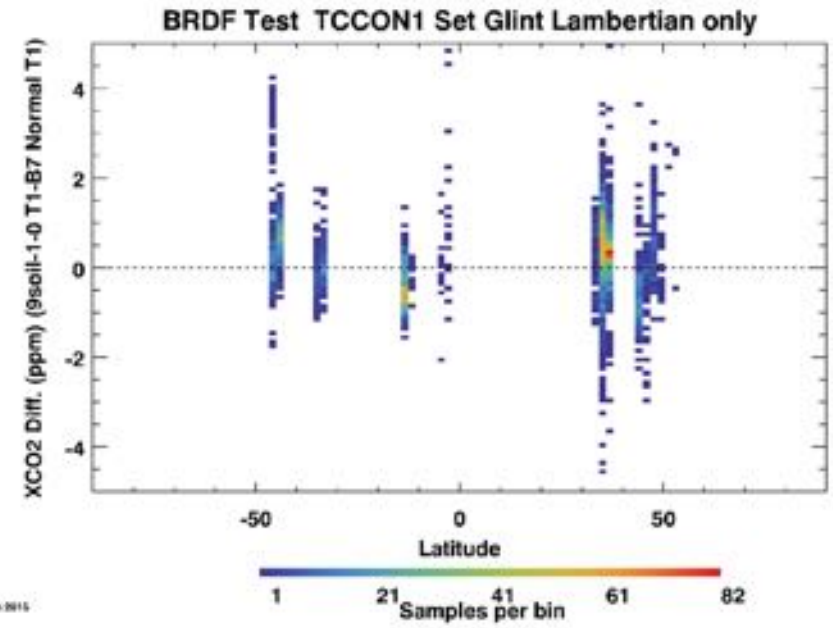


Albedo uncorrelated with scattering angle for BRDF models; BRDF models also produce more filtered, converged soundings

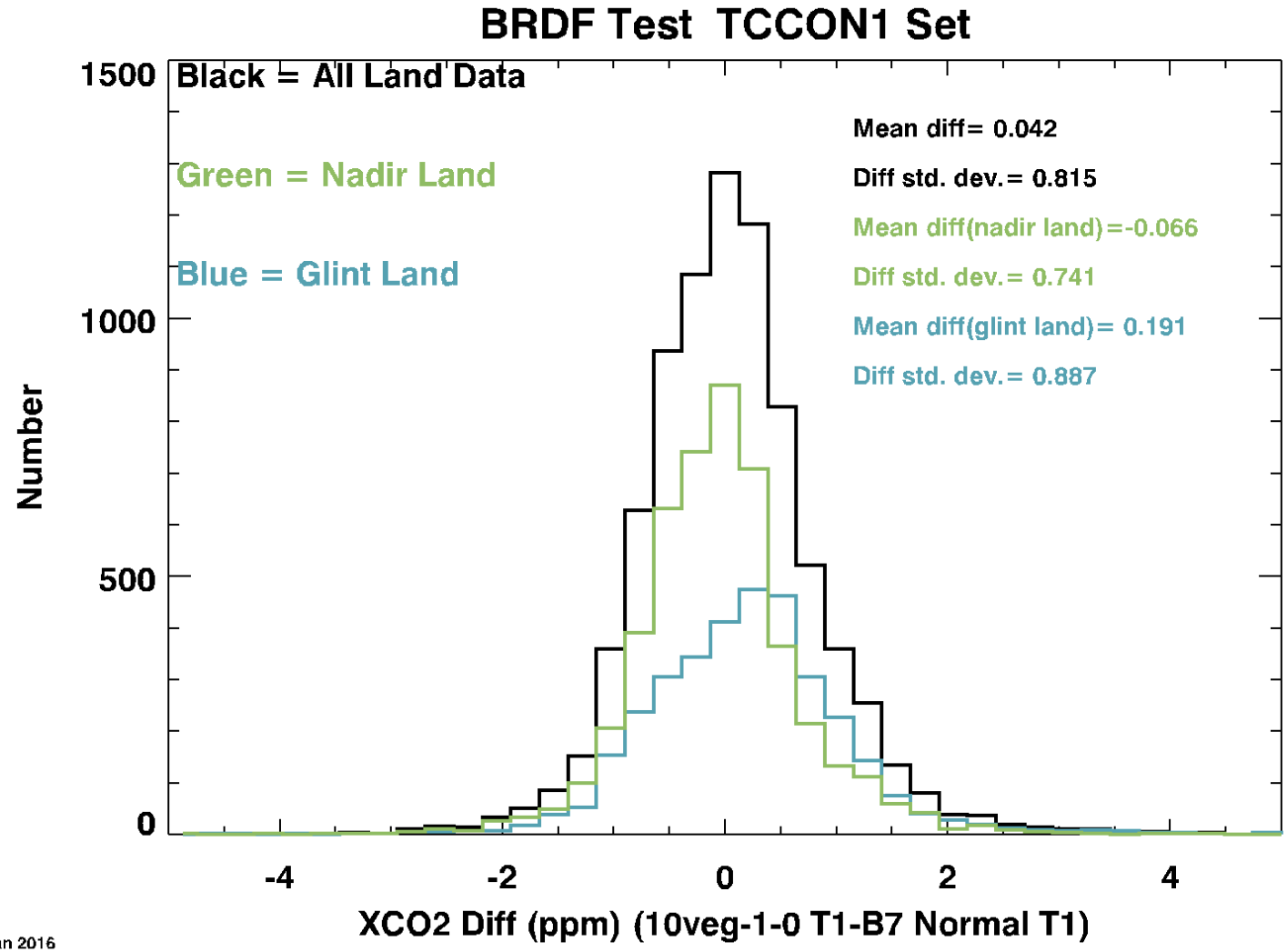
Glint Mode Tests

XCO2 Difference (Land Glint Only)



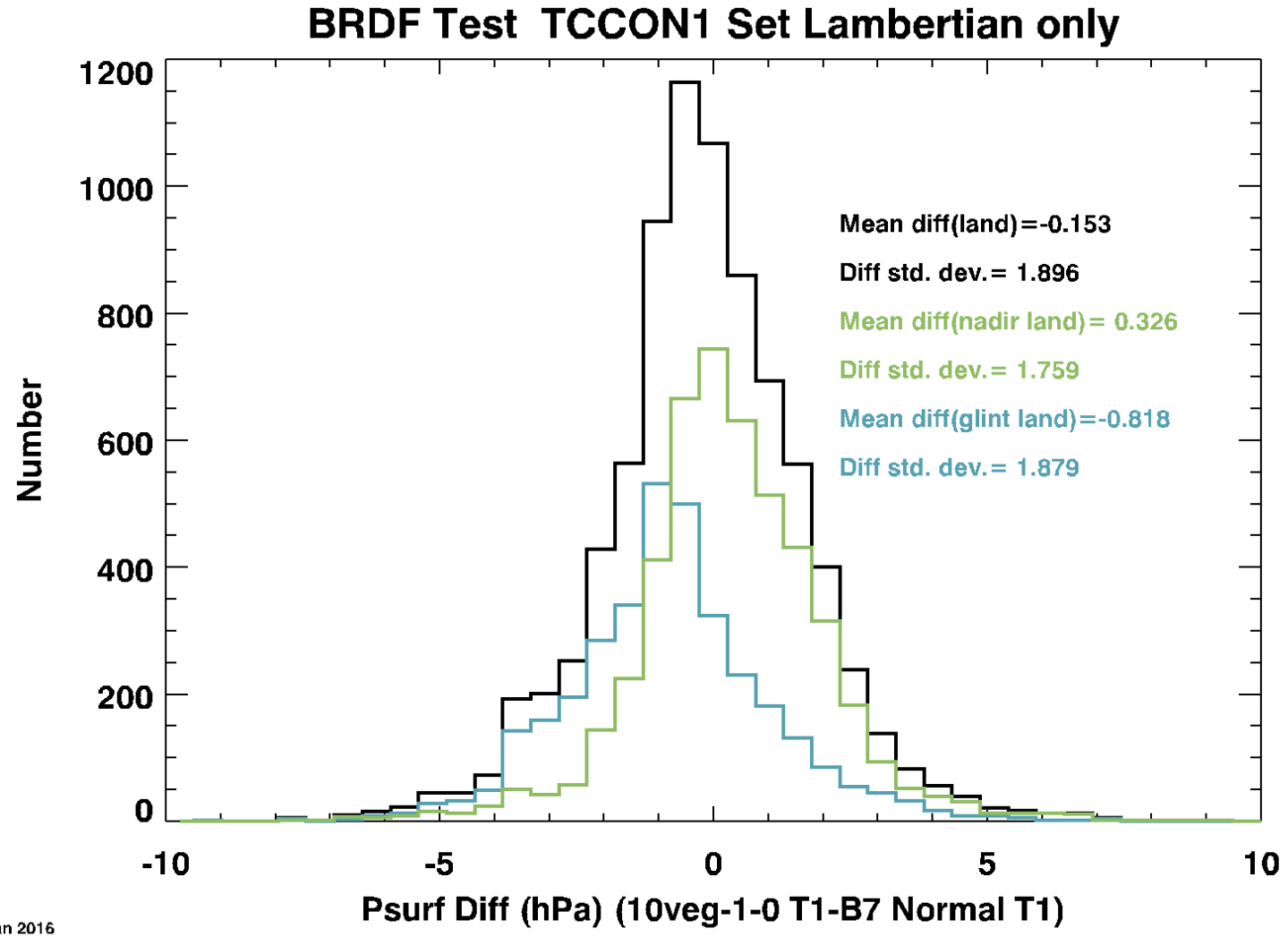


XCO2 Difference Histogram



26 Jan 2016

Psurf Difference Histogram



26 Jan 2016

Unfiltered Small Area Land Tests

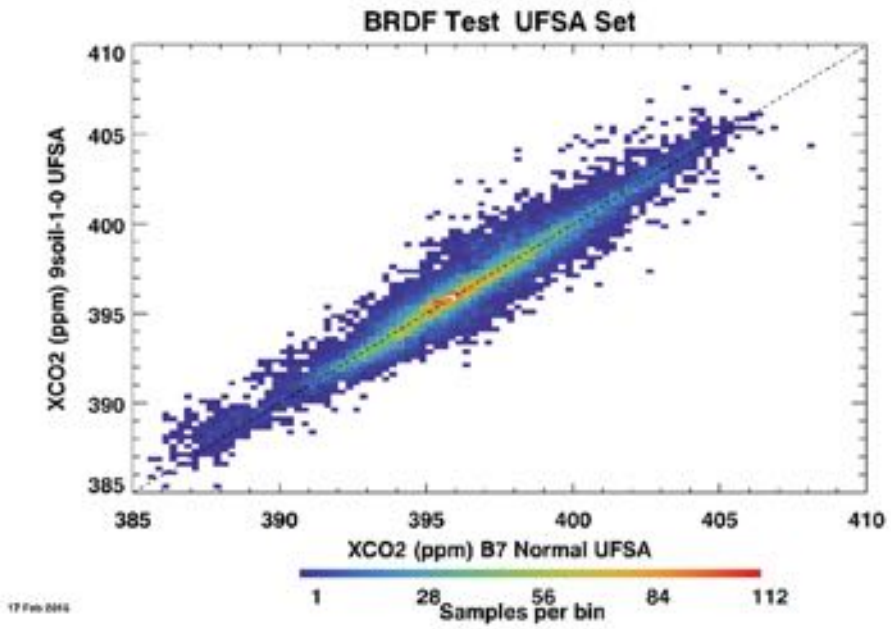
Convergence Statistics

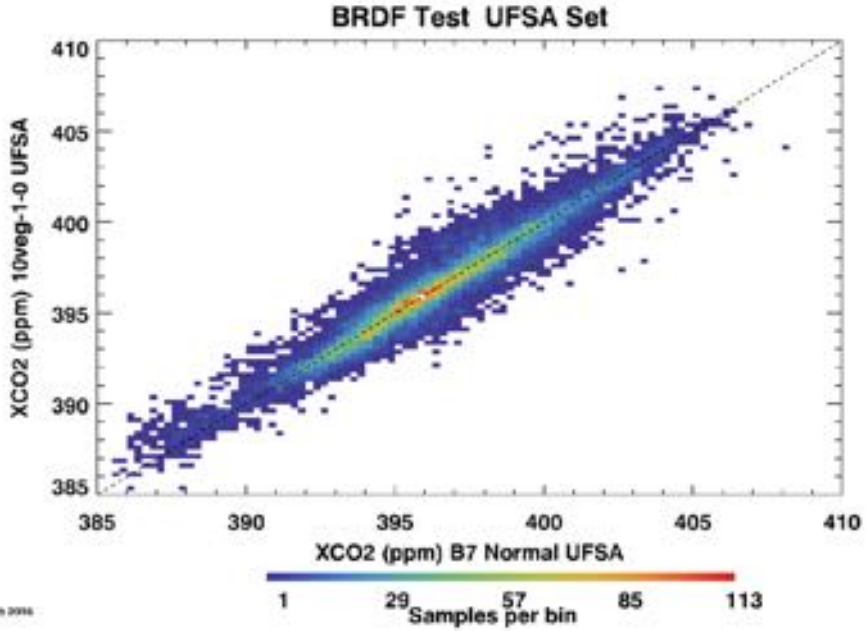
- **Number of soundings**
  - **B7 Baseline: 41873**
  - **Soil: 42551**
  - **Vegetation: 42550**

- **Converged**
  - **B7 Baseline: 36035 (86.06%)**
  - **Soil: 42539 (99.97%)**
  - **Vegetation: 42541 (99.98%)**

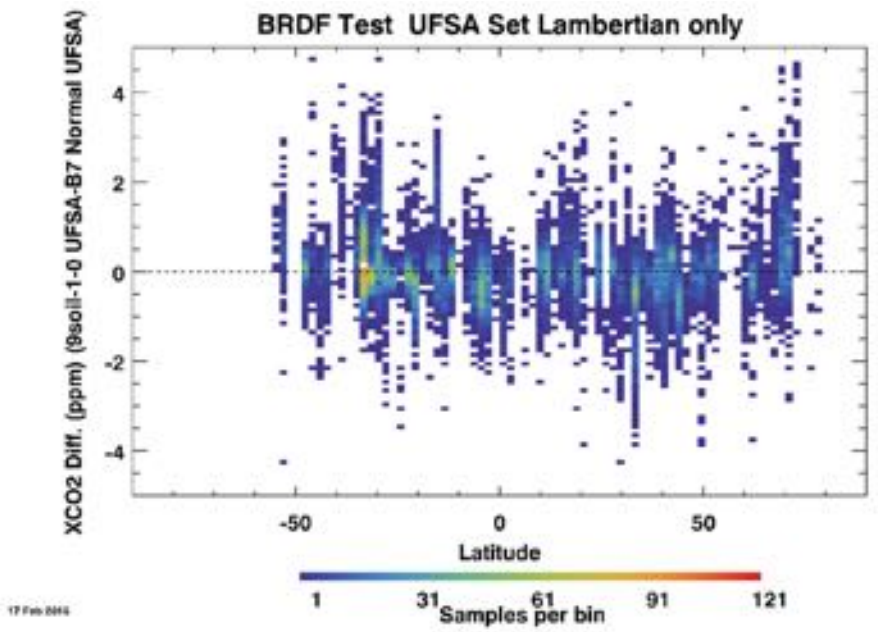
- **Good Quality**
  - **B7 Baseline: 12958 (30.95%)**
  - **Soil: 15239 (35.81%)**
  - **Vegetation: 15210 (35.75%)**

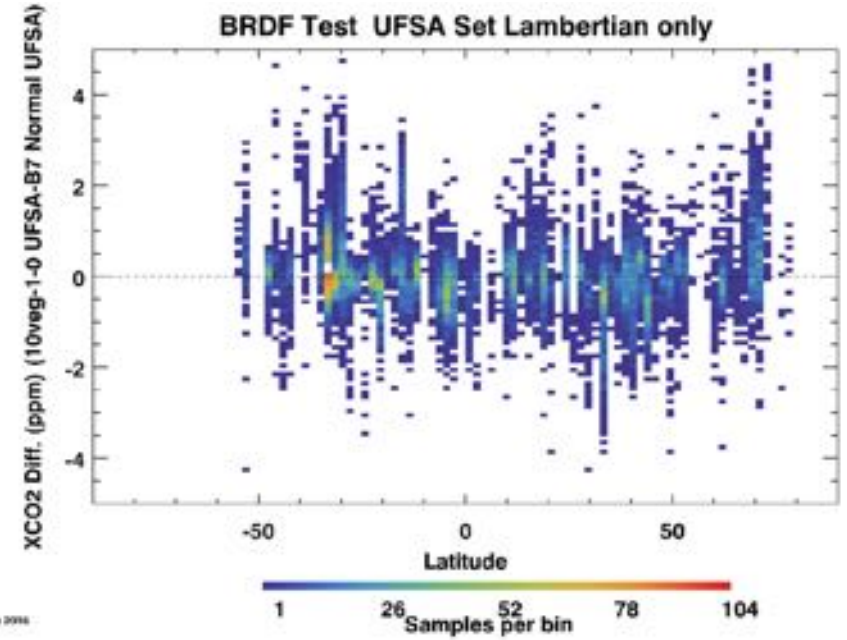
XCO2


BRDF Test UFSA Set
XCO2 (ppm) 9soil-1-0 UFSA
410
405
400
395
390
385
385
390
395
400
405
410
XCO2 (ppm) B7 Normal UFSA
1
28
56
84
112
Samples per bin

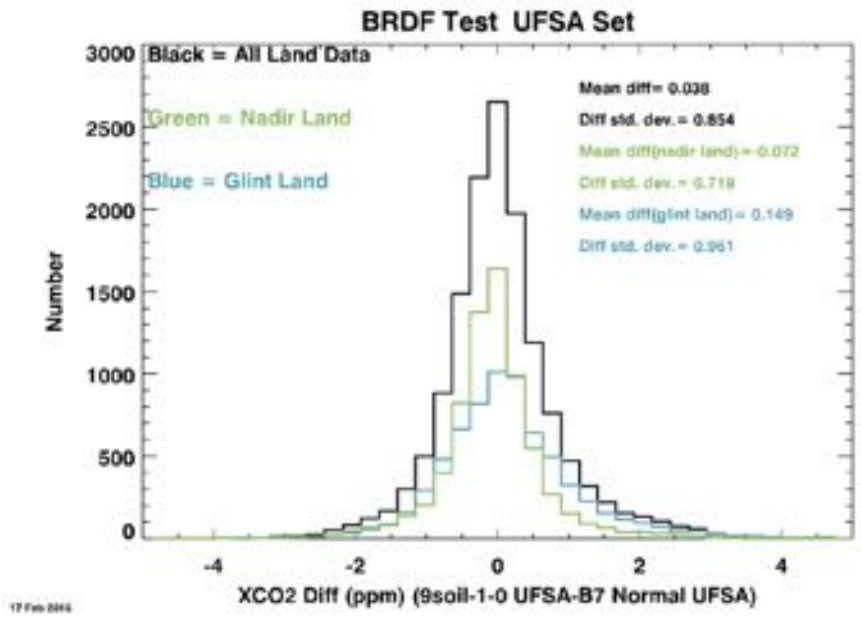

BRDF Test UFSA Set
XCO2 (ppm) 10veg-1-0 UFSA
410
405
400
395
390
385
385
390
395
400
405
410
XCO2 (ppm) B7 Normal UFSA
1
29
57
85
113
Samples per bin

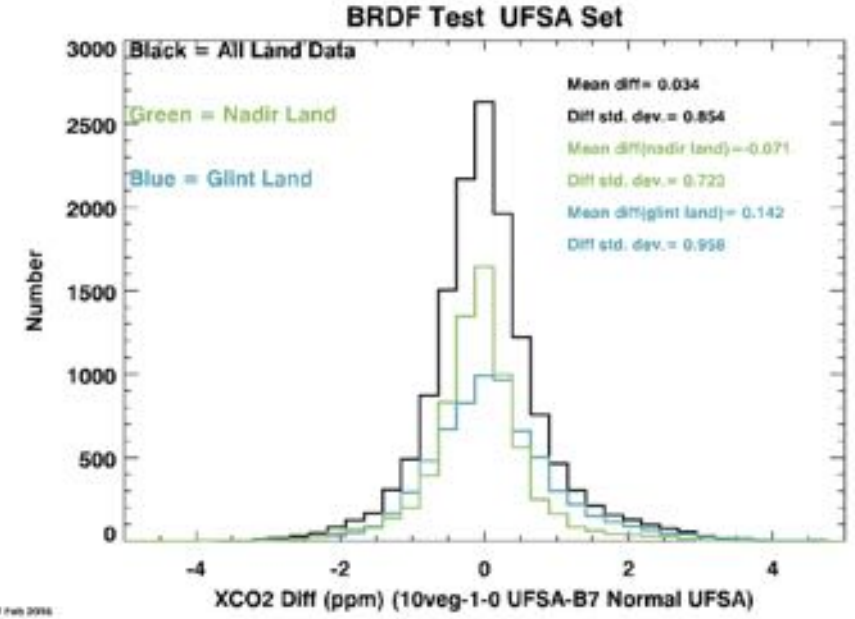
XCO2 Difference





XCO2 Difference Histogram





Next Steps

- **Re-baseline with new spectroscopic models**
- **How do we compare Lambertian and BRDF results?**
- **Implement BRDF model in operational code**