Radiometric comparison of GOSAT TANSO-FTS and Suomi NPP VIIRS 1.6 µm CO_2 absorption band

Sirish Uprety and Changyong Cao

CIRA, Colorado State University

NOAA/NESDIS/STAR

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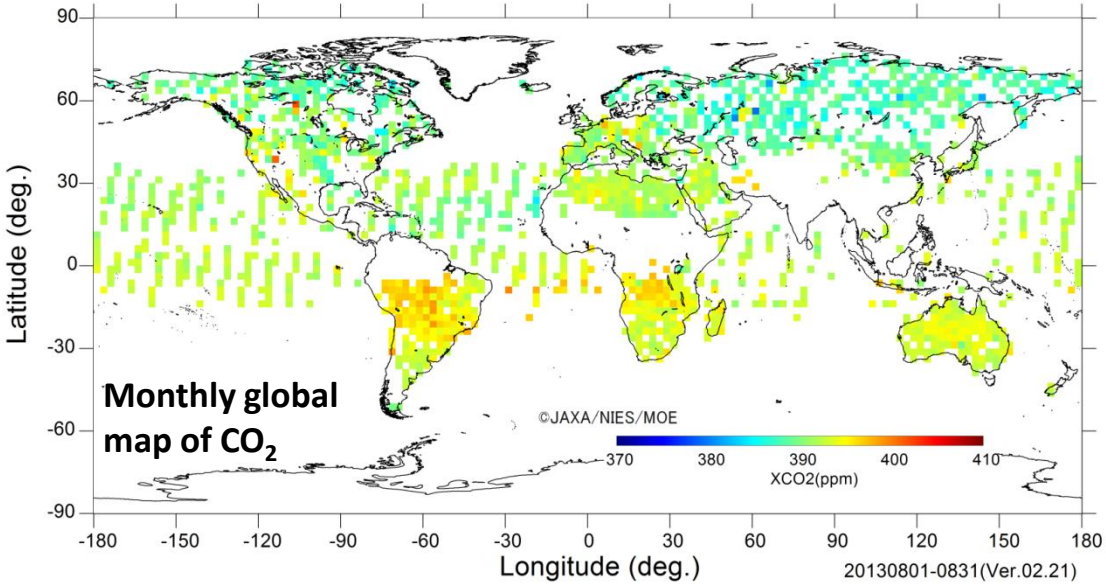
Objective and Background

- Evaluate the radiometric consistency between S-NPP VIIRS M10 (1.61 µm) and GOSAT TANSO-FTS band 2 (1.64 µm) that heps to better understand the calibration accuracy of the instruments.
- Radiometric performance can be independently analyzed through:
  - Onboard calibration system
  - Stable sites such as desert, ocean, snow, DCC.
  - Exo-terrestrial targets such as moon, stars etc.
  - Inter-calibration with other well calibrated radiometers (SNO/SNO-x, stable desert targets etc).
- VIIRS and TANSO-FTS radiometric consistency is analyzed using
  - TOA reflectance trending near Libya-4 desert site and
  - Extended SNOs based intercomparison over low latitudes (SNOx)
  - Radiometric comparison is performed between matching VIIRS band M10 with FTS band 2.

GOSAT

- The Greenhouse gases Observing SATellite (GOSAT) was launched on January 23, 2009
- GOSAT also called “IBUKI” is a cooperative project among JAXA, the National Institute for Environmental Studies (NIES) and the Ministry of the Environment (MOE).
- Payloads: Thermal and Near Infrared Sensor for Carbon Observation - Fourier Transform Spectrometer(TANSO-FTS) and a Cloud and Aerosol Imager (TANSO-CAI)
- 100 minute/orbit and 3 day repeat cycle
- Carbon Dioxide and methane are the primary retrieved greenhouse gases data product.



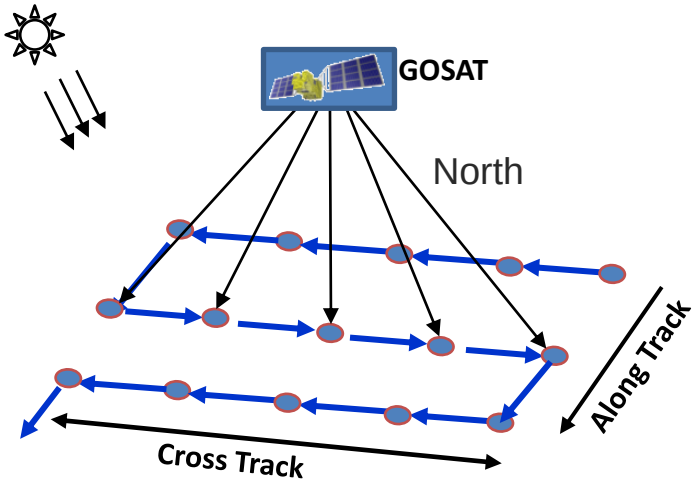


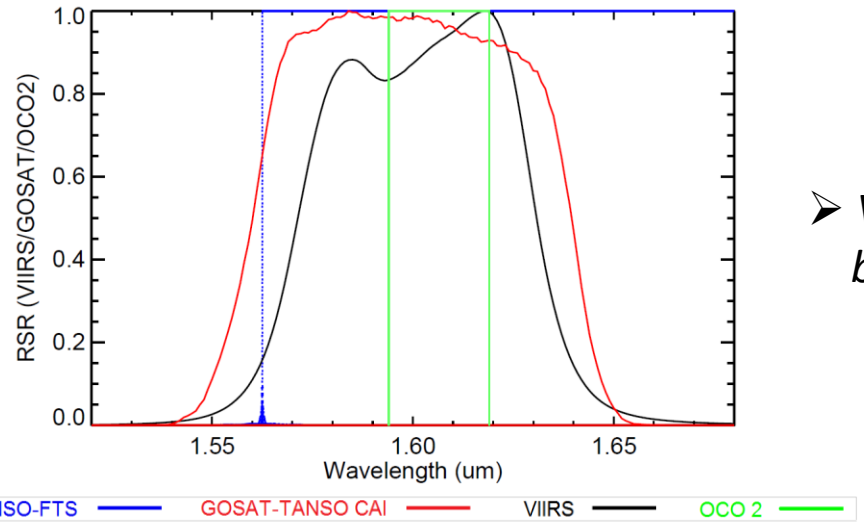
Figure 1. GOSAT TANSO-FTS operation

Ref: http://www.gosat.nies.go.jp

VIIRS and TANSO-FTS

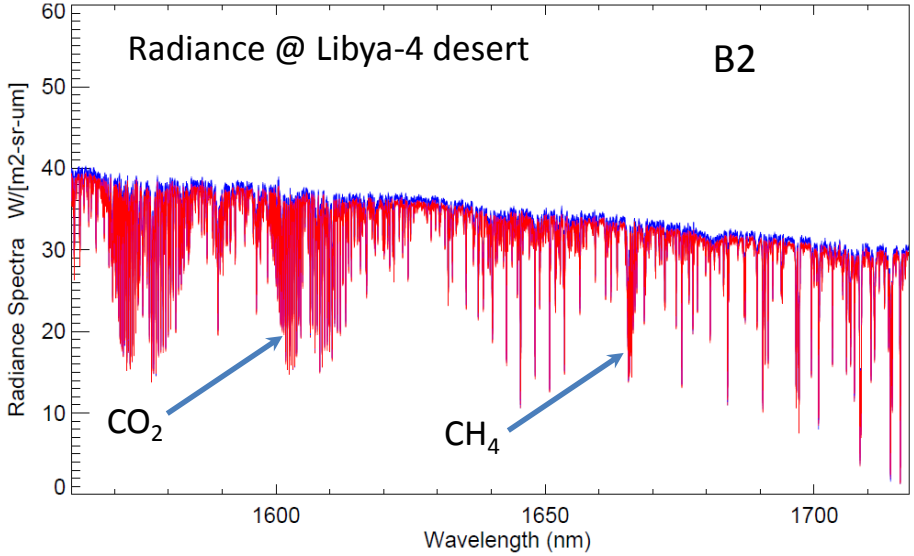
- **VIIRS** is a Sun-synchronous polar orbiting instrument launched in October 2011.
- Multispectral scanning radiometer with 16 moderate resolution bands (0.4 µm to 12 µm), 5 Imagery bands (0.6 µm to 12 µm) and 1 day night band (DNB).
- wide-swath: 3,000 km, spatial resolution: 750m for moderate resolution bands and DNB , 375 m for imagery bands.
- Equipped with solar diffuser (SD) and black body as onboard calibrators.

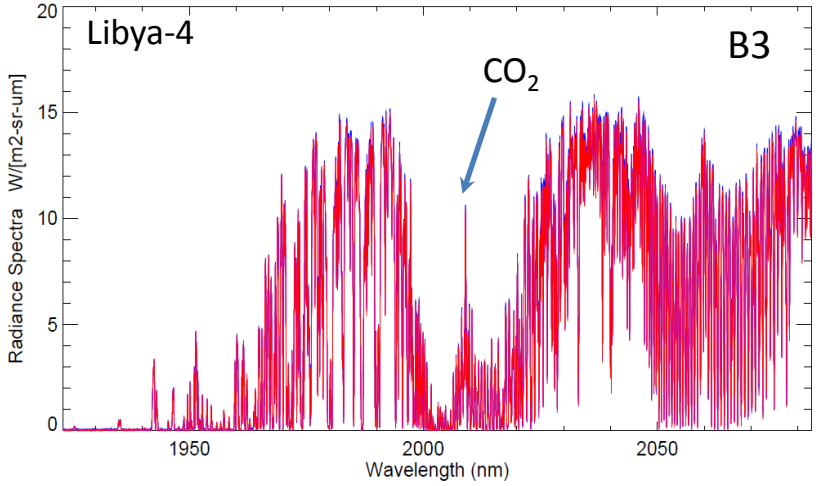
- **TANSO-FTS**:
  - RSB bands: 0.76, 1.64, and 2.00 um with Spatial Resolution: ~10.5 km
  - Spectral resolution: 0.2 wavenumbers (about 0.05 nm at 1.6 µm)
- TANSO-FTS takes 56,000 measurements over 3-day period.
- Incoming light splits into two orthogonally polarized components (P and S components) and measured independently.
- FTS Calibration: Solar Irradiance, Deep Space, Moon, Diode Laser.

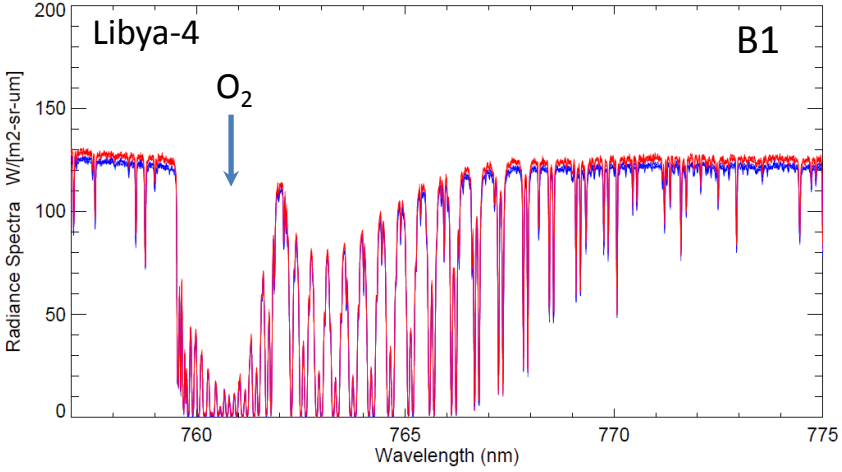


➢ *VIIRS M10 is covered by FTS band 2*

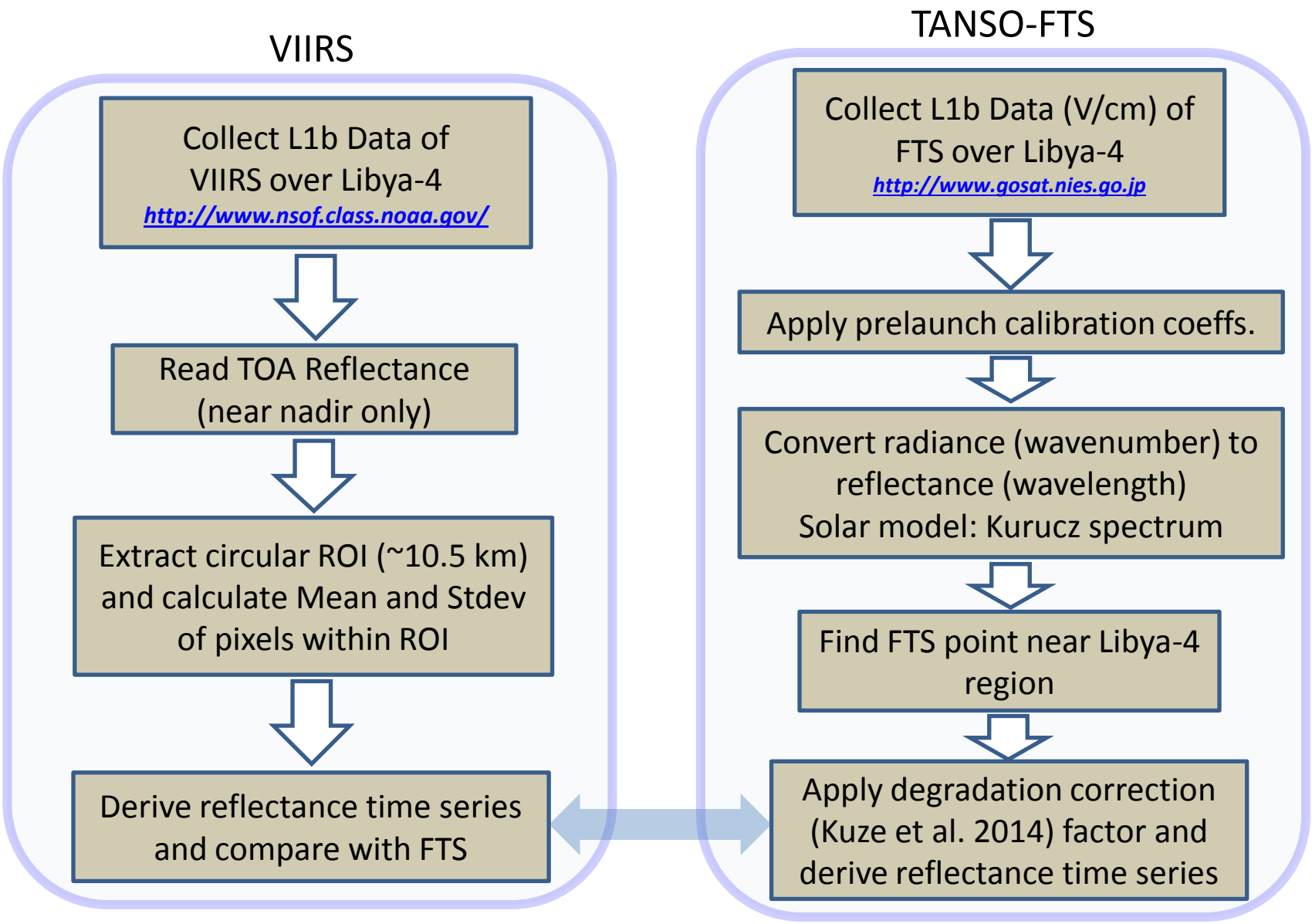
FTS Radiance Spectra



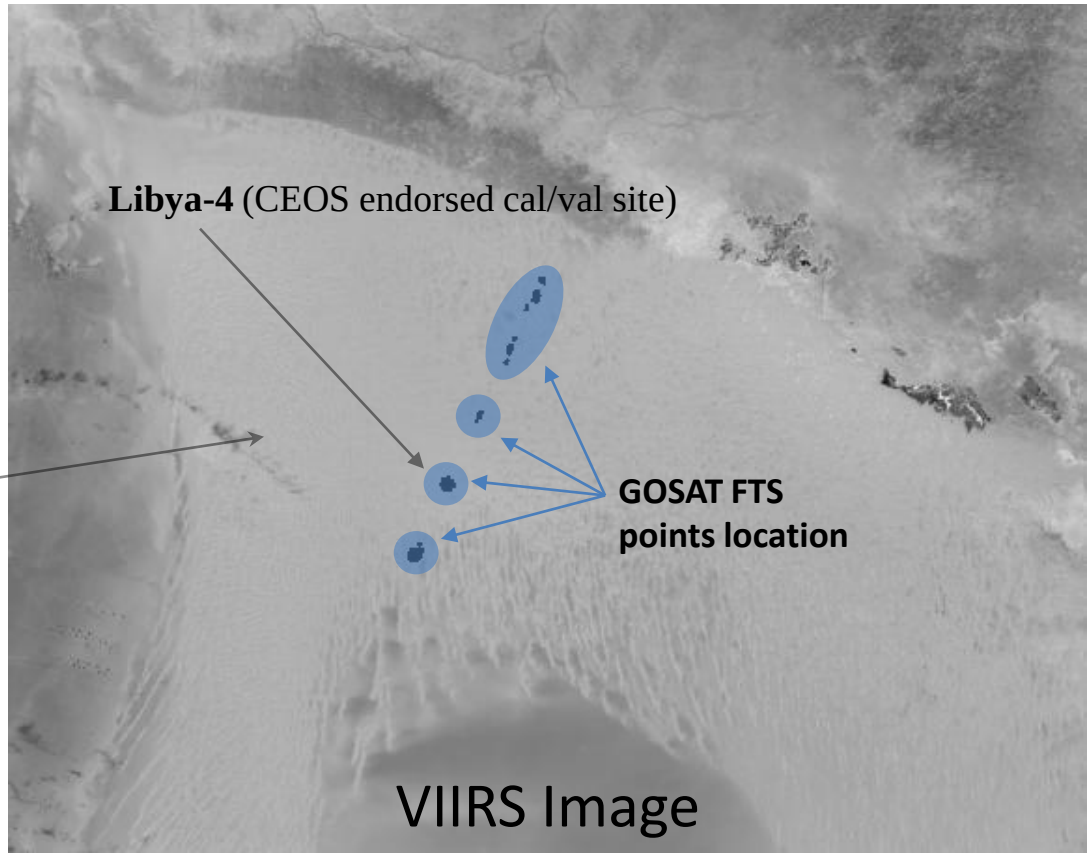




VIIRS/FTS Comparison Methodology



GOSAT FTS ROIs used in Time Series



- FTS reflectance time series over Libya-4 is based on above observations.
- Since the ROIs are located at different lat/lon, the reflectance can be different and constructing a time series without properly adjusting for the target-dependent reflectance can add bias among these ROIs and also add larger variability

1.6 µm CO_2 Band

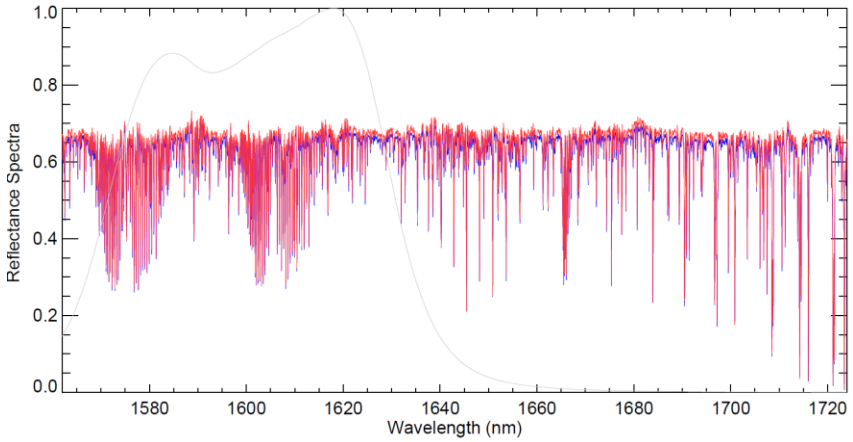


Figure 1. Using wavelength range from Instrument Specification

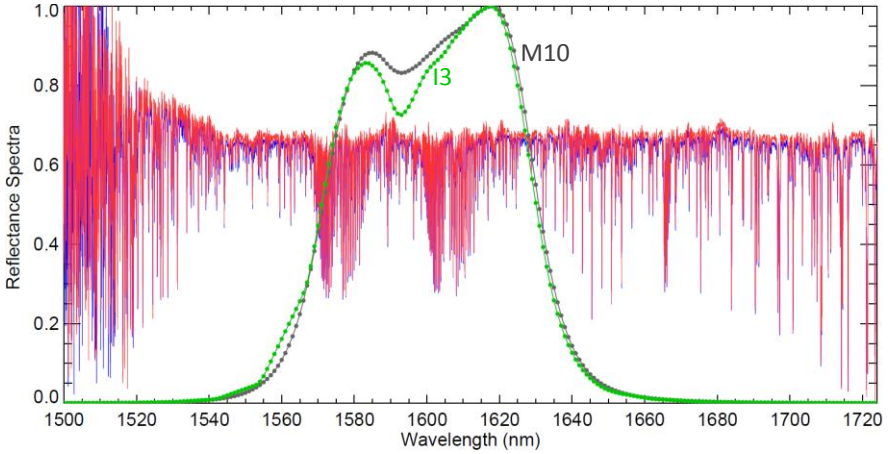
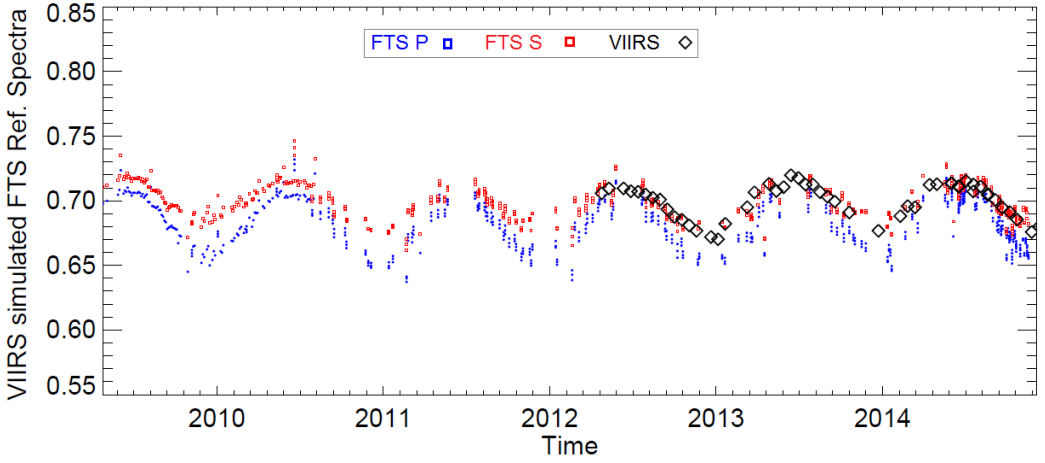


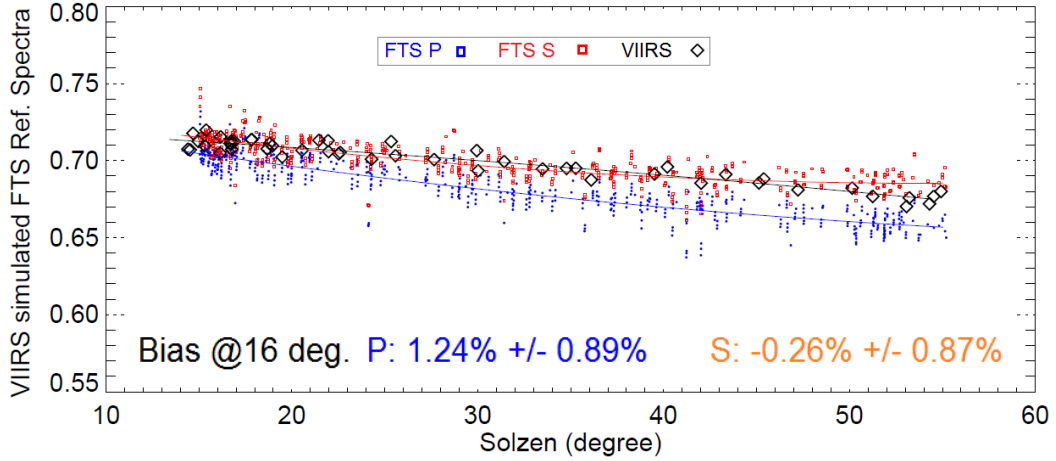
Figure 2.Using longer spectral range available in L1B data

- Since desert spectra is in general flat for most of the wavelength coverage of M10 from 1540 to 1562 nm, the convolution suggest:
  - By using VIIRS RSR=0 for wavelength < 1562 nm, convolved Reflectance= 61.422%
  - By using all VIIRS RSR values, convolved Reflectance= 61.379%
  - Using convolved radiance, the difference with/without cutoff at 1562nm is about 0.2%. eg. 47.28 vs 47.18 w/m2sr/um at Libya-4
- The impact is insignificant over desert!

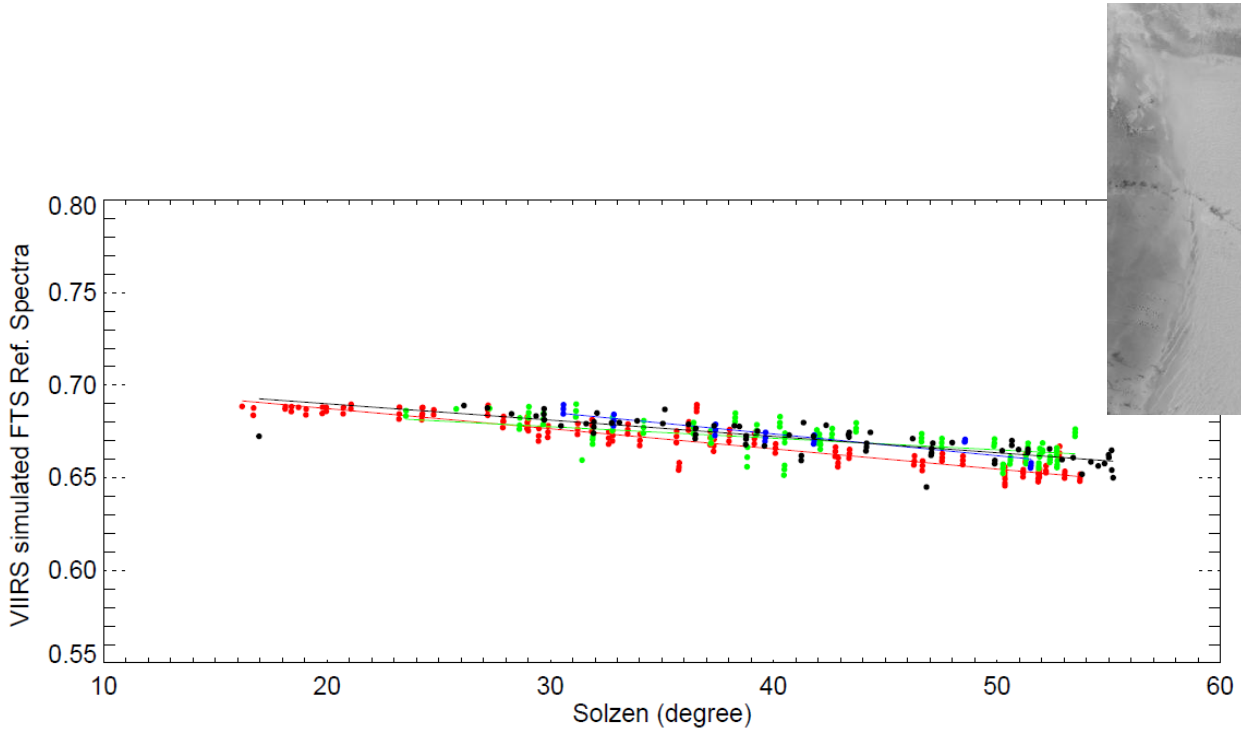
Preliminary Result
TOA Reflectance Comparison

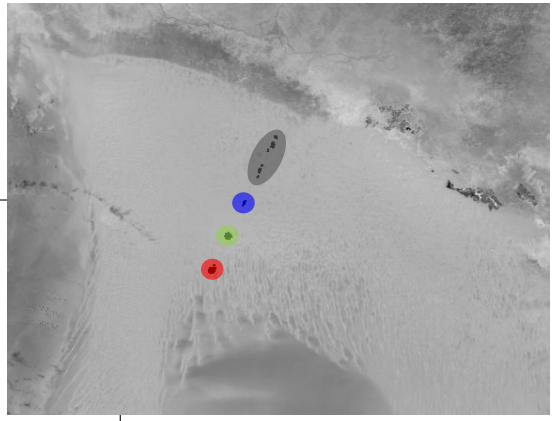
- Figure shows the near-nadir TOA reflectance time series for VIIRS and FTS observations over Libya-4 region.
- Annual seasonal variation mainly due to the changing solar geometry.
- Relative bias for P polarization measurements is larger than that of S polarization
- VIIRS and S polarized observations agree very well to within 0.3% with uncertainty less than 1%.
- Larger radiometric inconsistency exist between VIIRS and P polarized measurements ranging from about 1.2% @ 16° solar zenith to nearly 3% at 55° solar zenith.





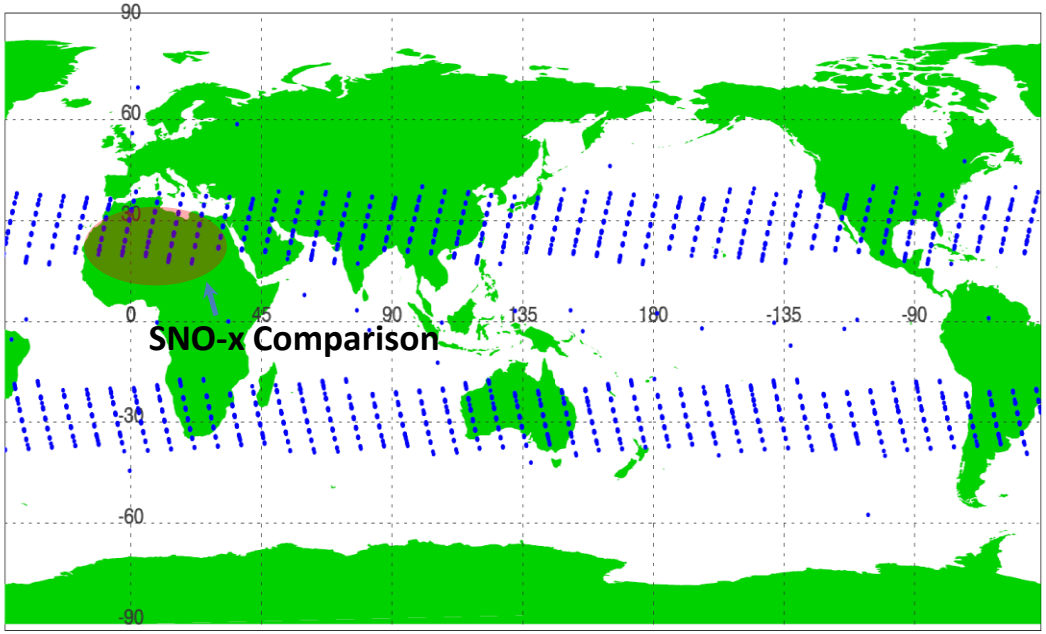
FTS Target Location Variation

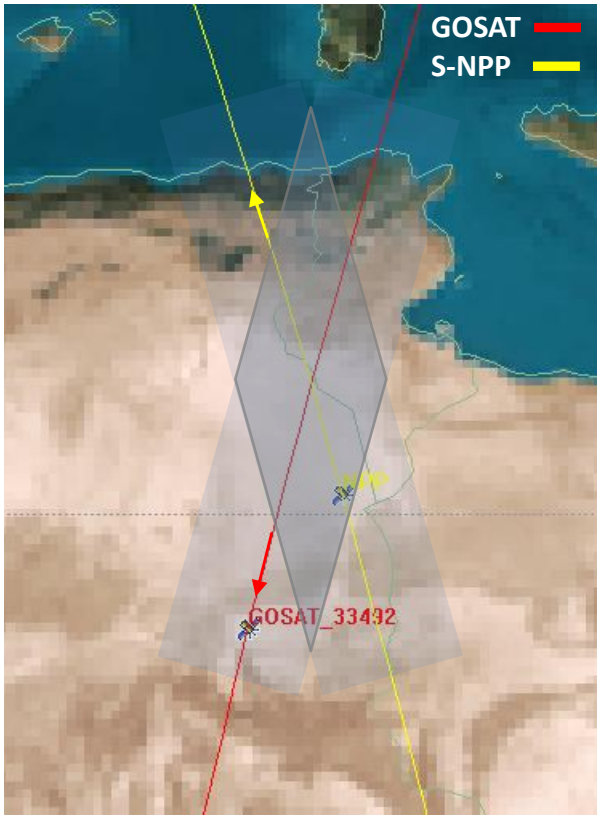




- Up to 1% uncertainty is added due to the variation in location of FTS observation near Libya-4 region
- Scaling factors can be estimated and applied to account for the differences and reduce the uncertainty .

Extended Simultaneous Nadir Overpass
NPP and GOSAT SNO





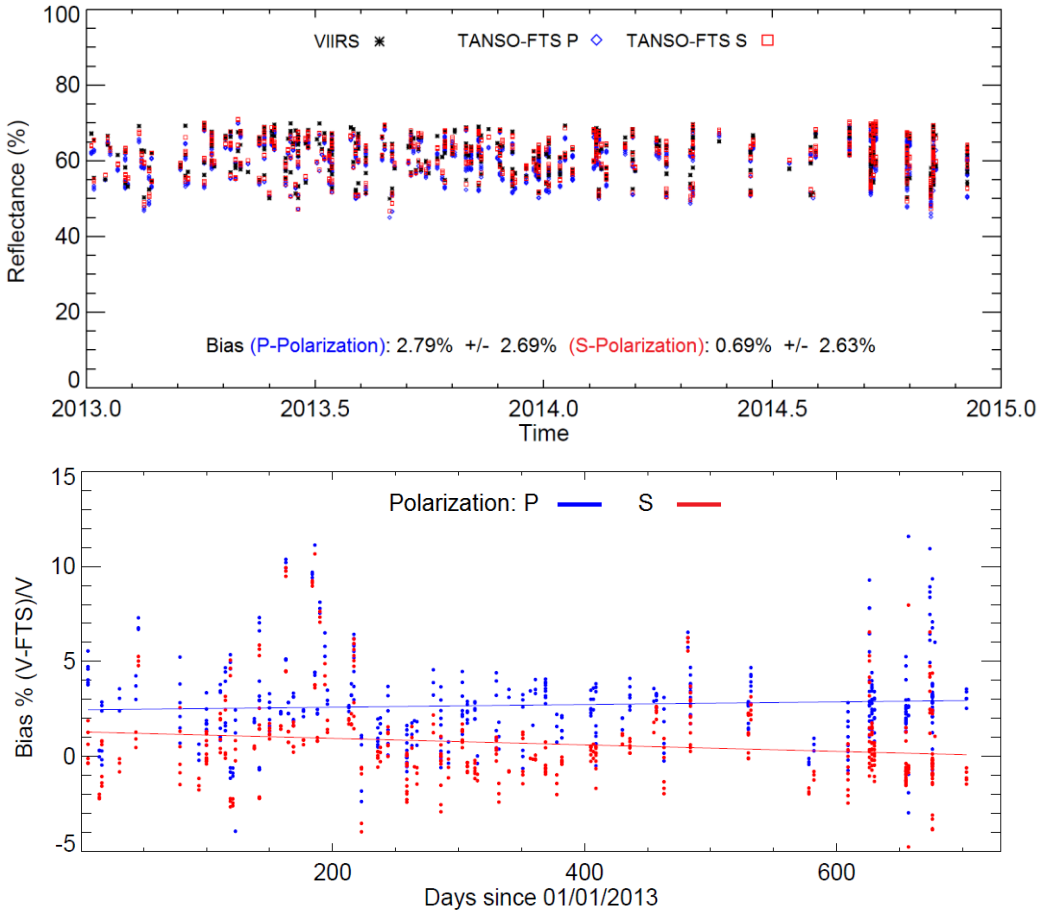
Total SNO-x: 8085 with Time Difference=10 minutes

- SNO events at low latitudes
- Only North African Deserts are used in this study
- SNO time difference of few minutes causes the movement of clouds and its shadows.
- Latitude limits: ±40°. ***Bias=(VIIRS – FTS)*100%/VIIRS***

➢ SNO-x Comparison:
  - Diamond shaped overlapping region

Preliminary Results

- Relative bias between VIIRS and FTS is less than 1% for S polarization
- Bias for P polarization ranges from nearly 2% to 4% with varying solar zenith angles.
- Bias time series is very noisy with 1-sigma uncertainty larger than 2% for both P and S polarized measurements.
- Collocation errors and cloud contamination can be primary sources of uncertainty.
- Needs more investigation.



Summary

- VIIRS and TANSO-FTS compared using TOA reflectance trending and extended SNOs over low latitudes.
- Intercomaprison over Libya-4 desert suggest that VIIRS and S polarized FTS measurements are radiometrically consistent to within 0.5% ± 0.9%.
- For VIIRS and P polarized light, estimated bias ranges from about 1.5% at smallest solar zenith angle that increases to nearly 3% at largest solar zenith angle observed.
- The result over Libya-4 agree in general with the SNO-x results however, SNO-x suggest much larger uncertainty of more than 2% for both P and S polarized light.
- Bias estimated using SNO-x is within 1% for S polarization whereas it ranges from 2-4% for P polarized light.
- CAI product will be used in future for cloud masking of FTS observations to reduce the uncertainty.