Requirements for accurate radiative transfer simulation to support vicarious calibration

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CEOS WGCV IVOS 30

28 – 29 March 2018, ESTEC, Noordwijk, the Netherlands

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This work is founded by the MetEOC-3 project

Overview

- Radiative transfer models play a critical role for vicarious calibration;
- Instruments like S2/MSI have proven to have a radiometric accuracy close to 2-3%;
- What is expected simulation accuracy with current RTMs over CEOS calibration sites: 1%, 3% or 5%?

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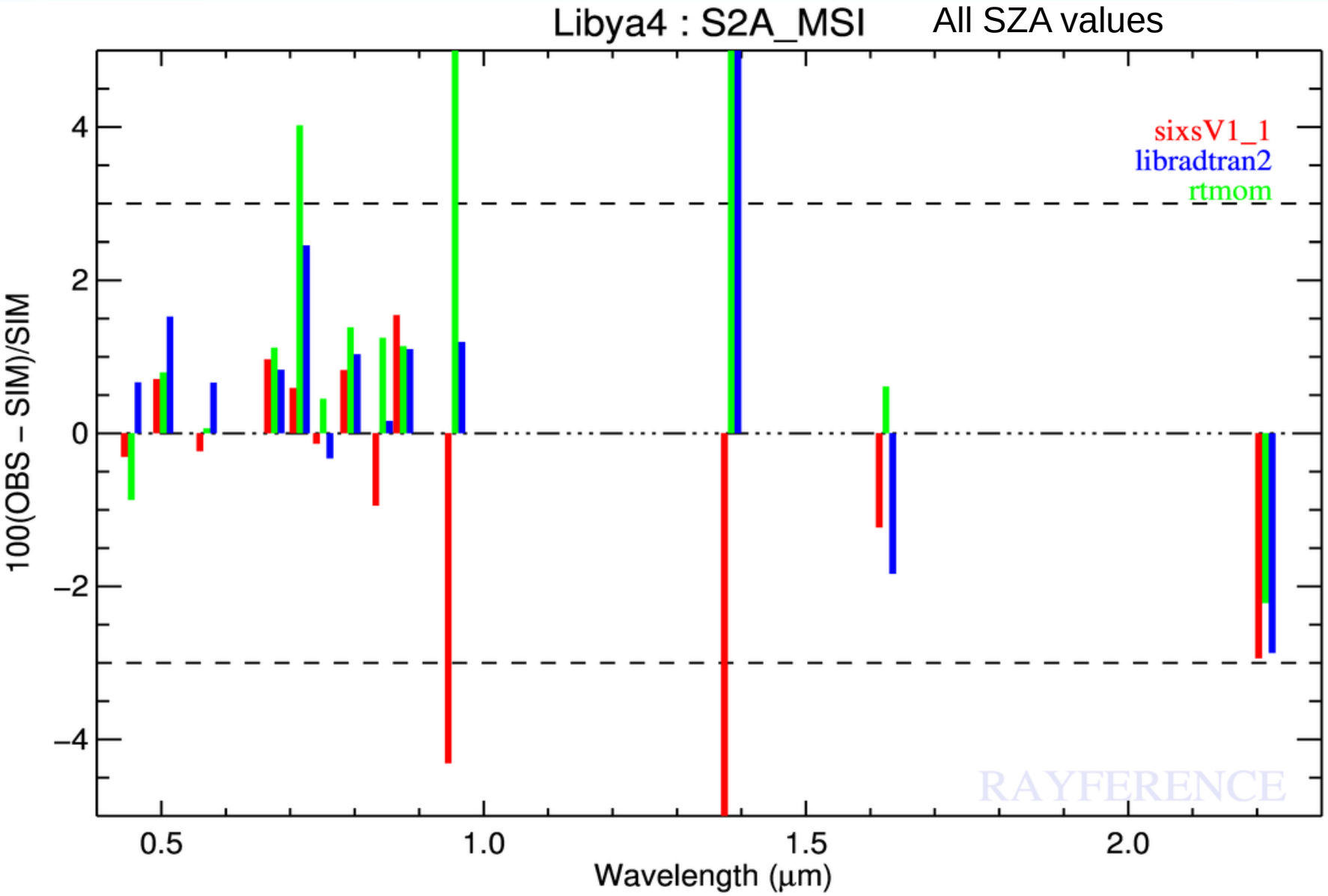
Experimental Setup

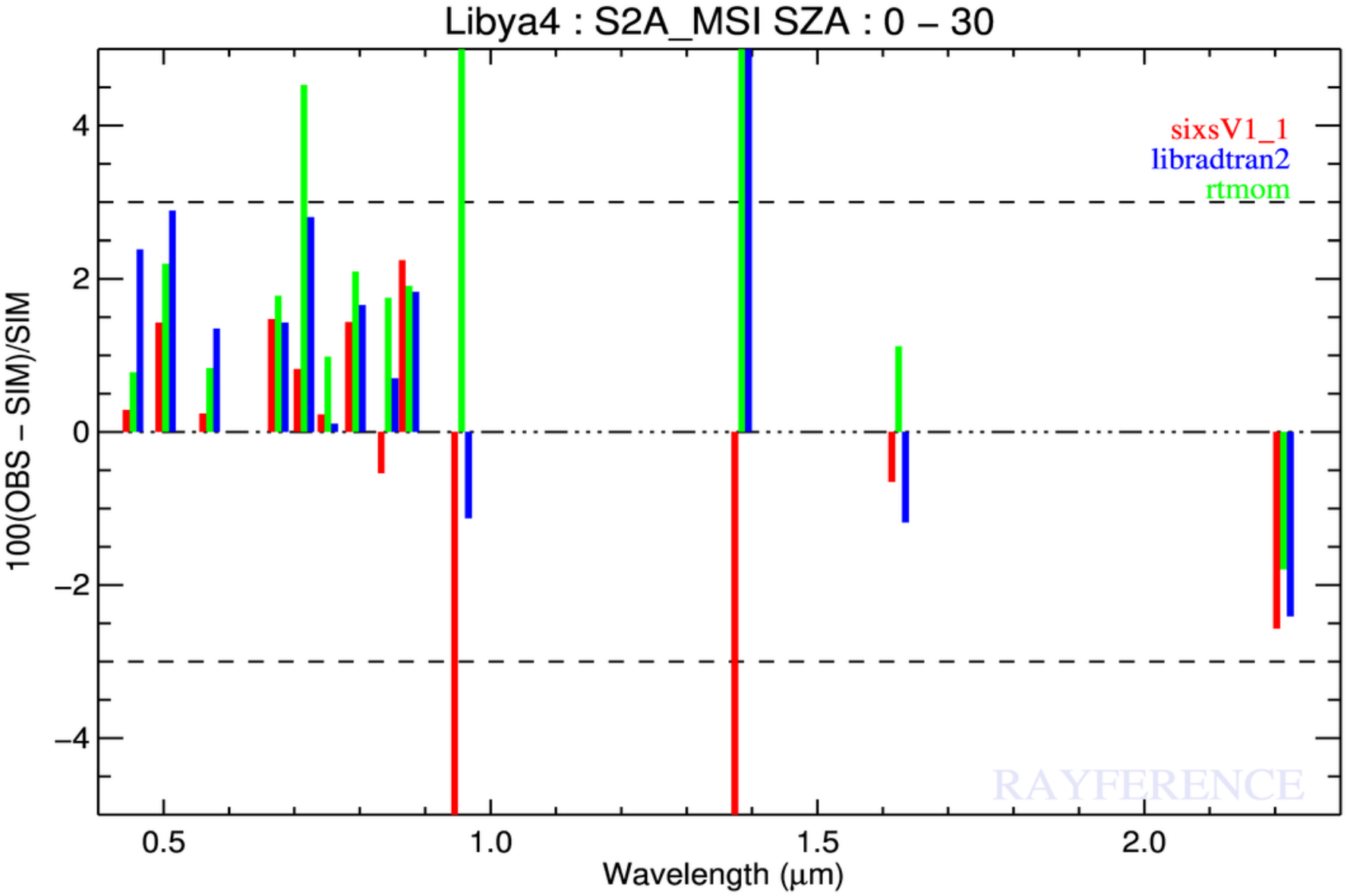
- Acquisition of TOA BRF over Libya-4 acquired by (PICSCAR)
  - Envisat/MERIS
  - AQUA/MODIS
  - S2A/MSI
  - L8/OLI
- Simulation of these TOA BRF with 3 different RTM fed with the same surface and aerosol properties (Govaerts et al., 2004, 2013)

Code	RTE solver	Gas
6S-V	Successive order	Hitran96
LibradtranV2	Monte Carlo	Hitran2012
RTMOM	Matrix Operator	Hitran96

S2A/MSI


Libya4 : S2A_MSI
All SZA values
sixsV1_1
libradtran2
rtmom
100(OBS – SIM)/SIM
4
2
0
–2
–4
0.5
1.0
1.5
2.0
Wavelength (µm)
RAYFERENCE

S2A/MSI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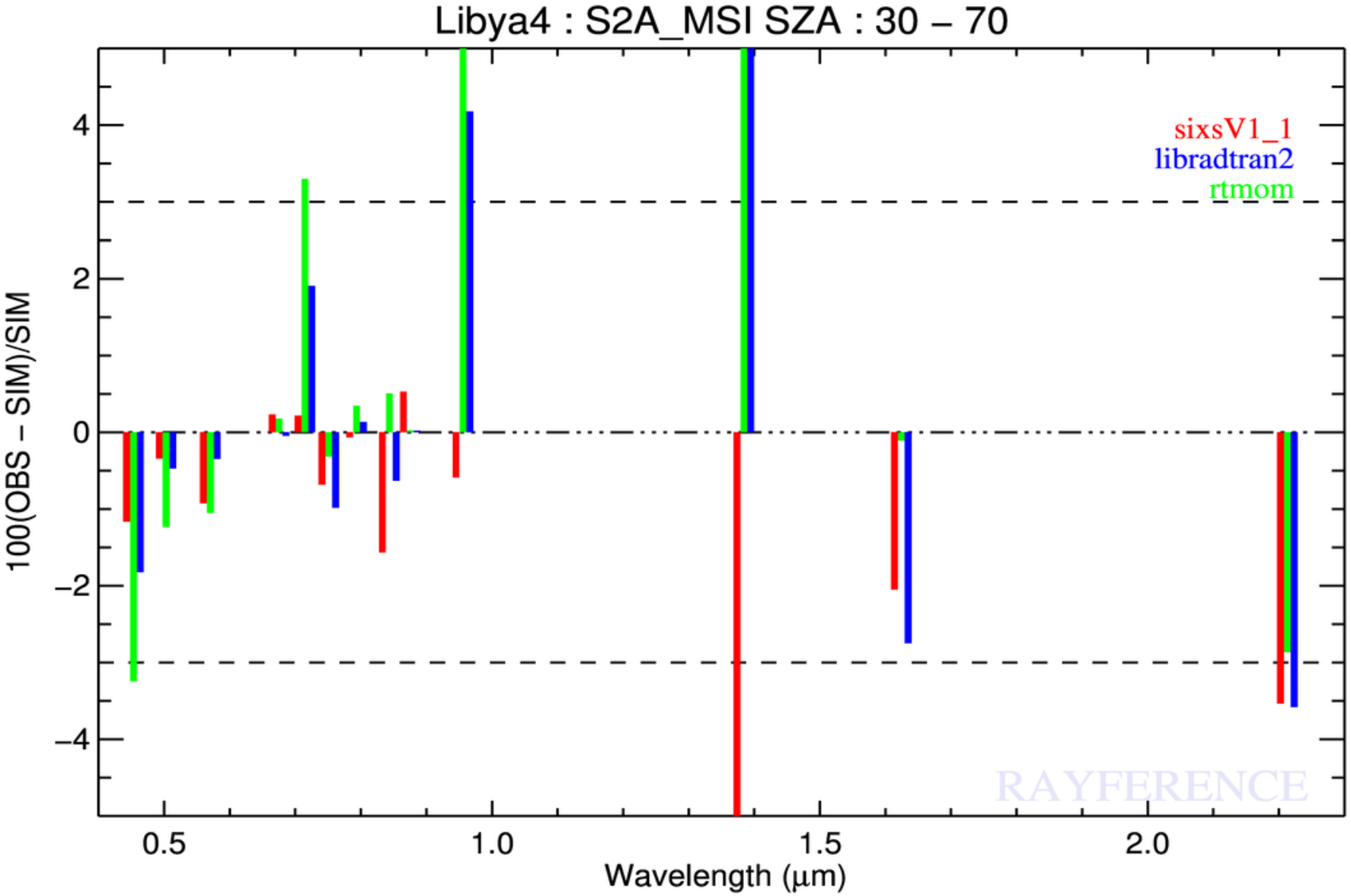
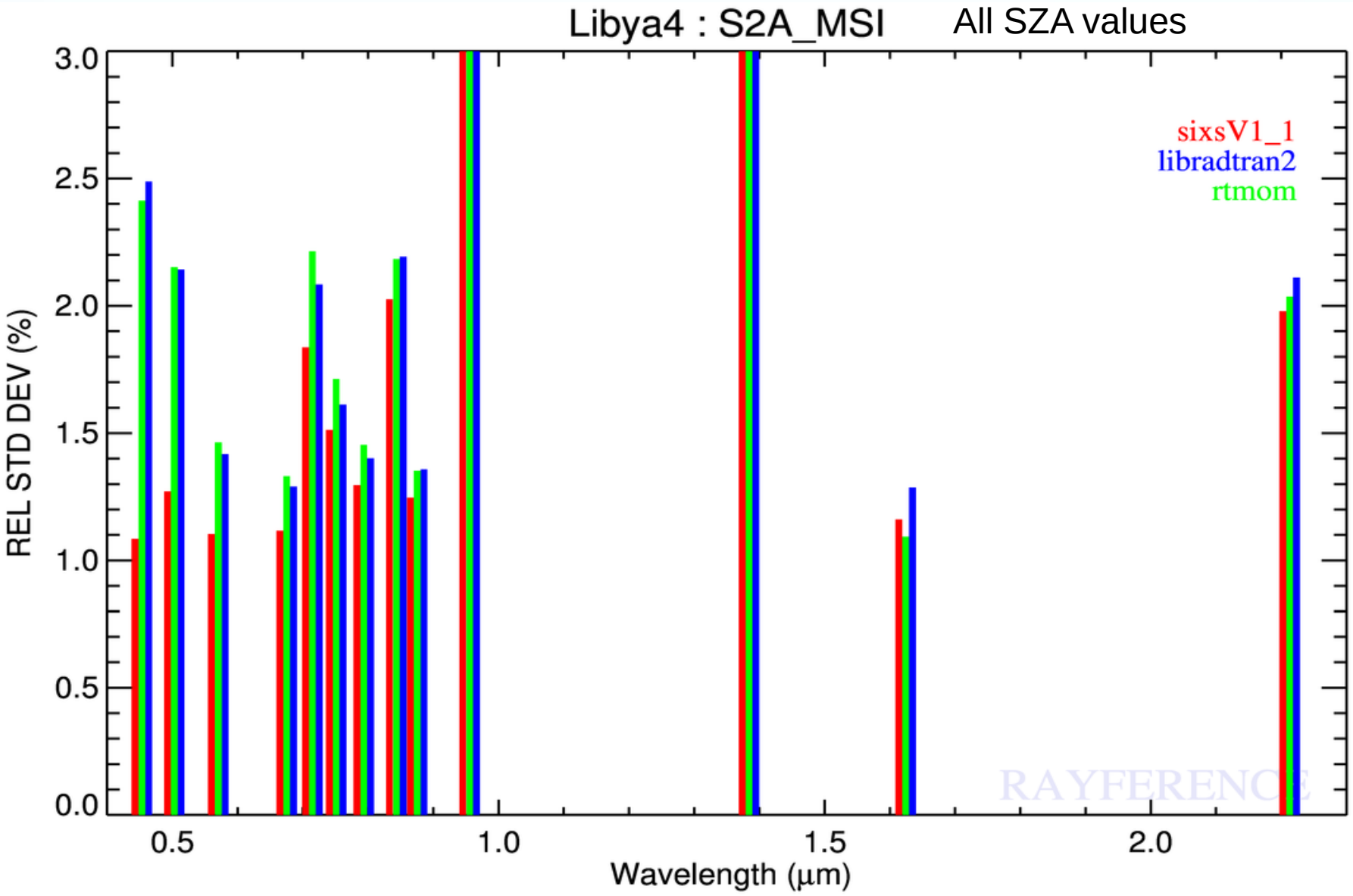
sixsV1_1
libradtran2
rtmom
100(OBS – SIM)/SIM
4
2
0
−2
−4
0.5
1.0
1.5
2.0
Wavelength (µm)
RAYFERENCE

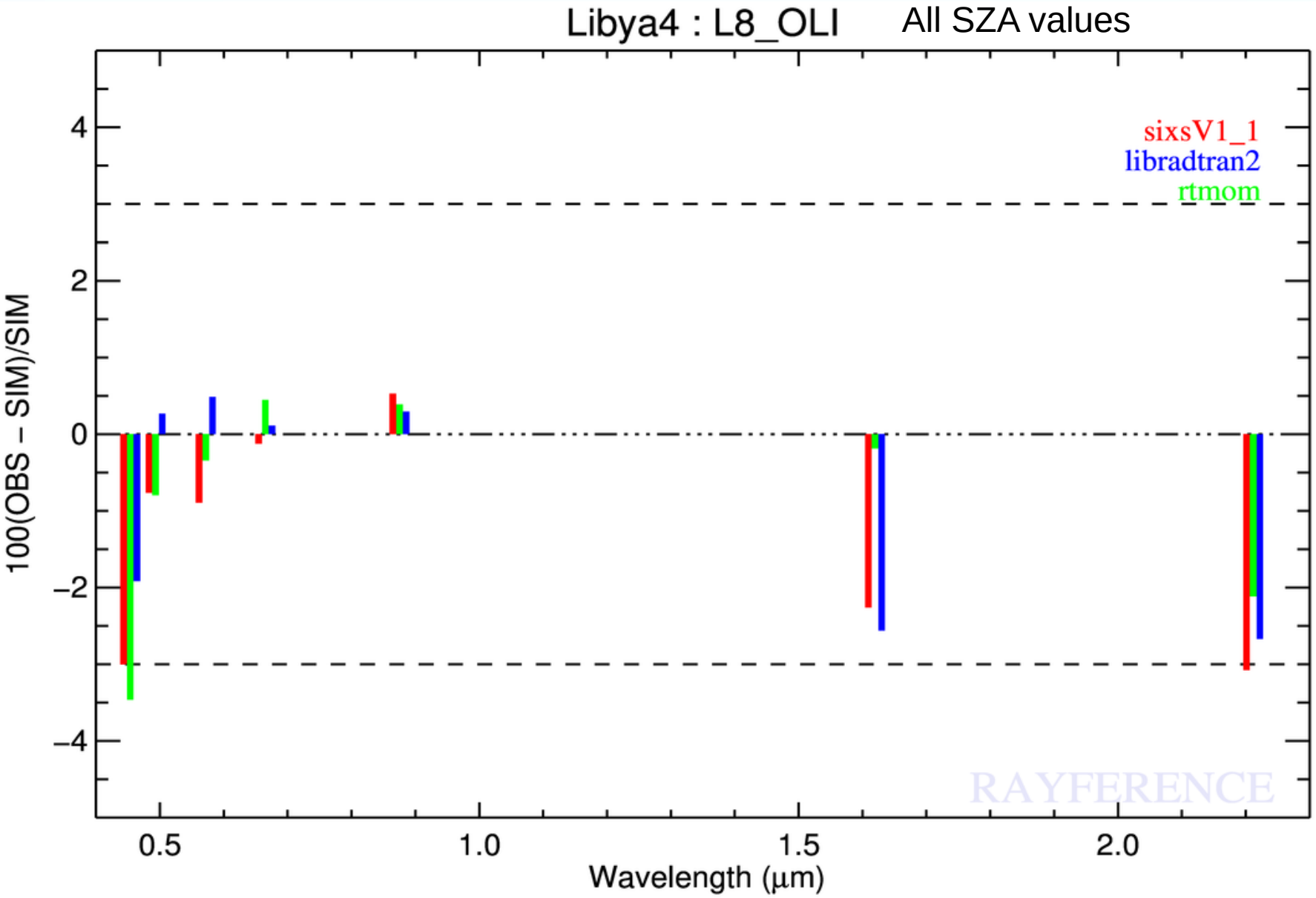
S2A/MSI


Libya4 : S2A_MSI SZA : 30 – 70
sixsV1_1
libradtran2
rtmom
100(OBS – SIM)/SIM
Wavelength (µm)
4
2
0
−2
−4
0.5
1.0
1.5
2.0
RAYFERENCE

S2A/MSI


Libya4 : S2A_MSI
All SZA values
sixsV1_1
libradtran2
rtmom
REL STD DEV (%)
Wavelength (µm)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.5
1.0
1.5
2.0
RAYFERENCE

L8/OLI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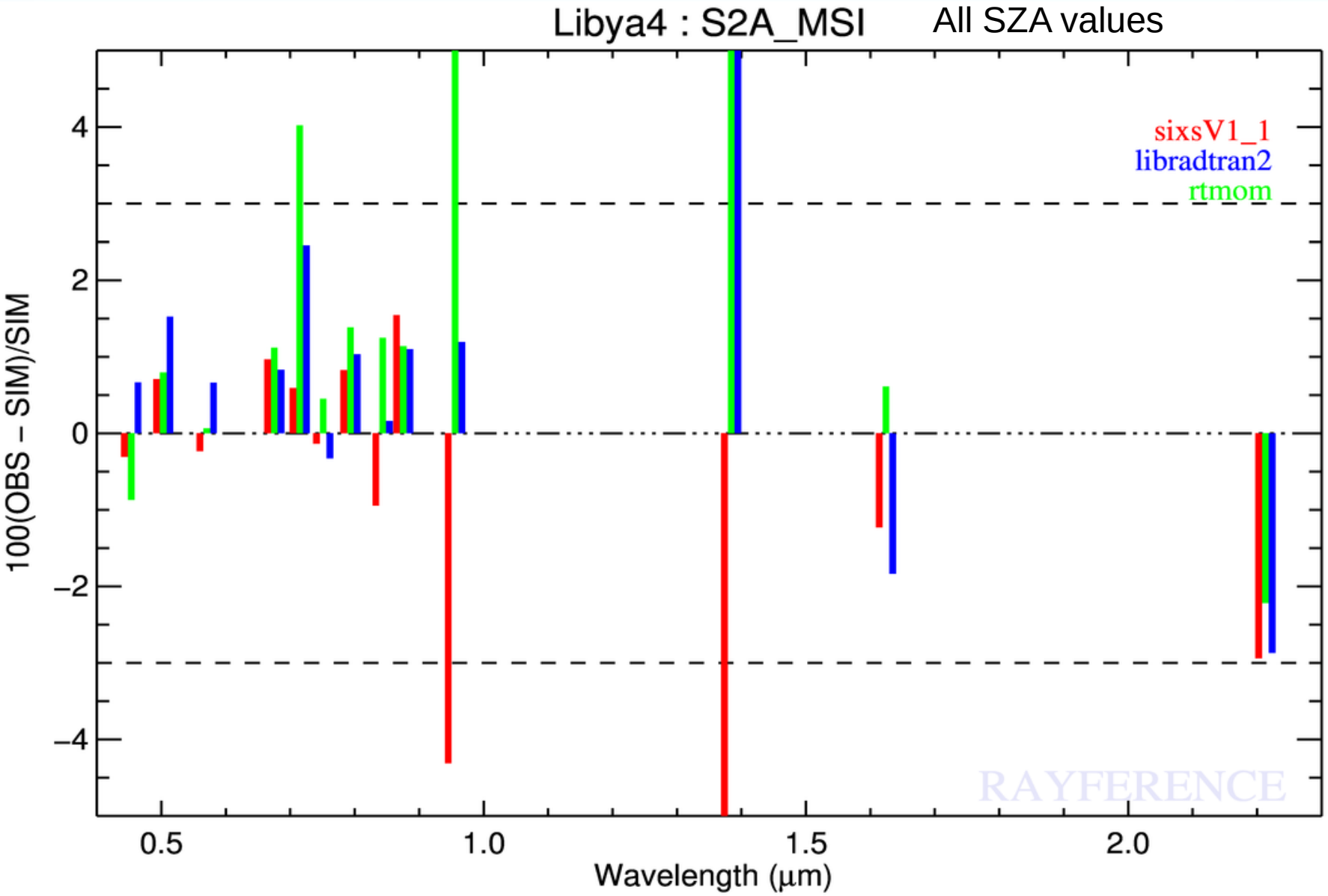
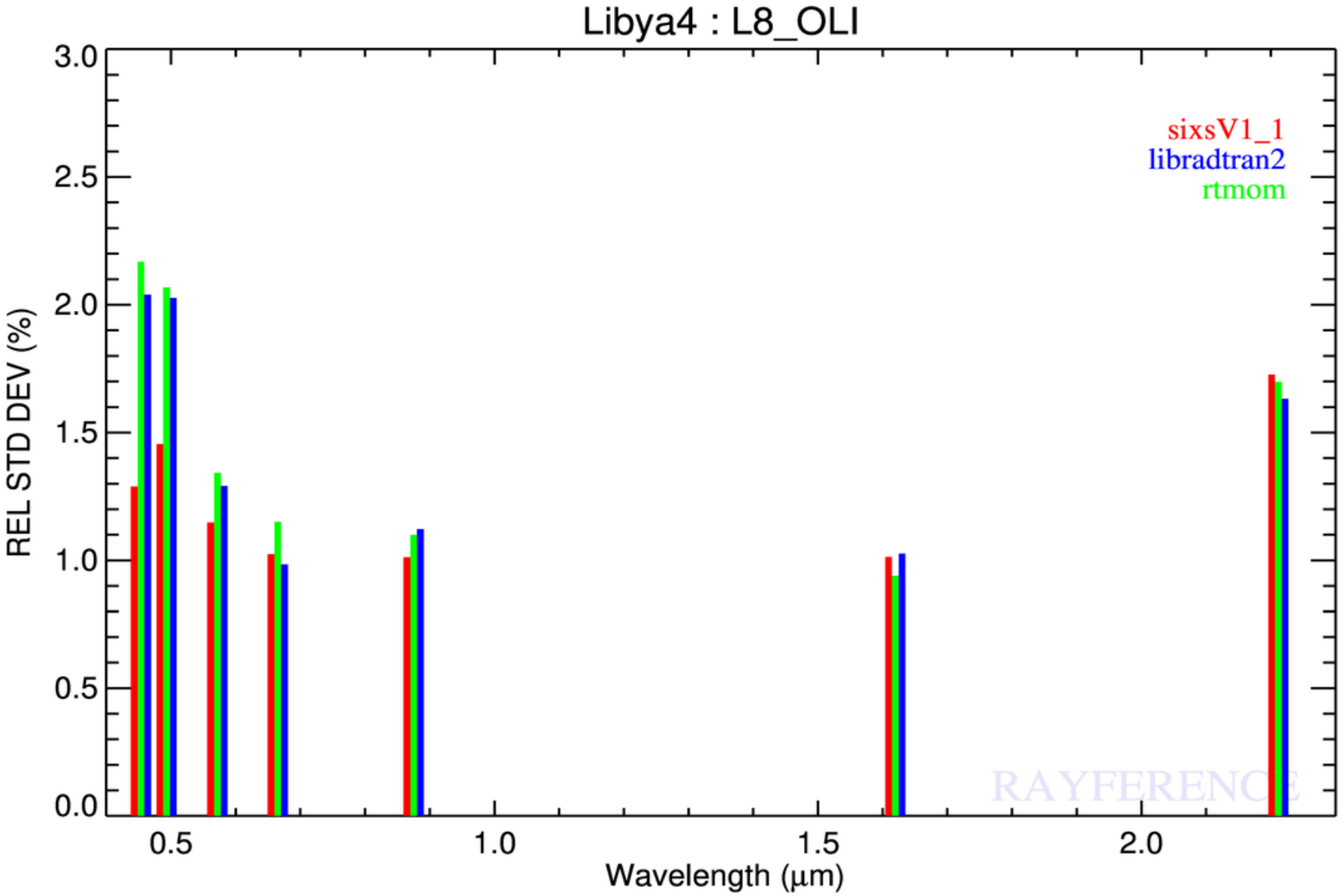
libradtran2
rtmom
100(OBS – SIM)/SIM
4
2
0
−2
−4
0.5
1.0
1.5
2.0
Wavelength (µm)
RAYFERENCE

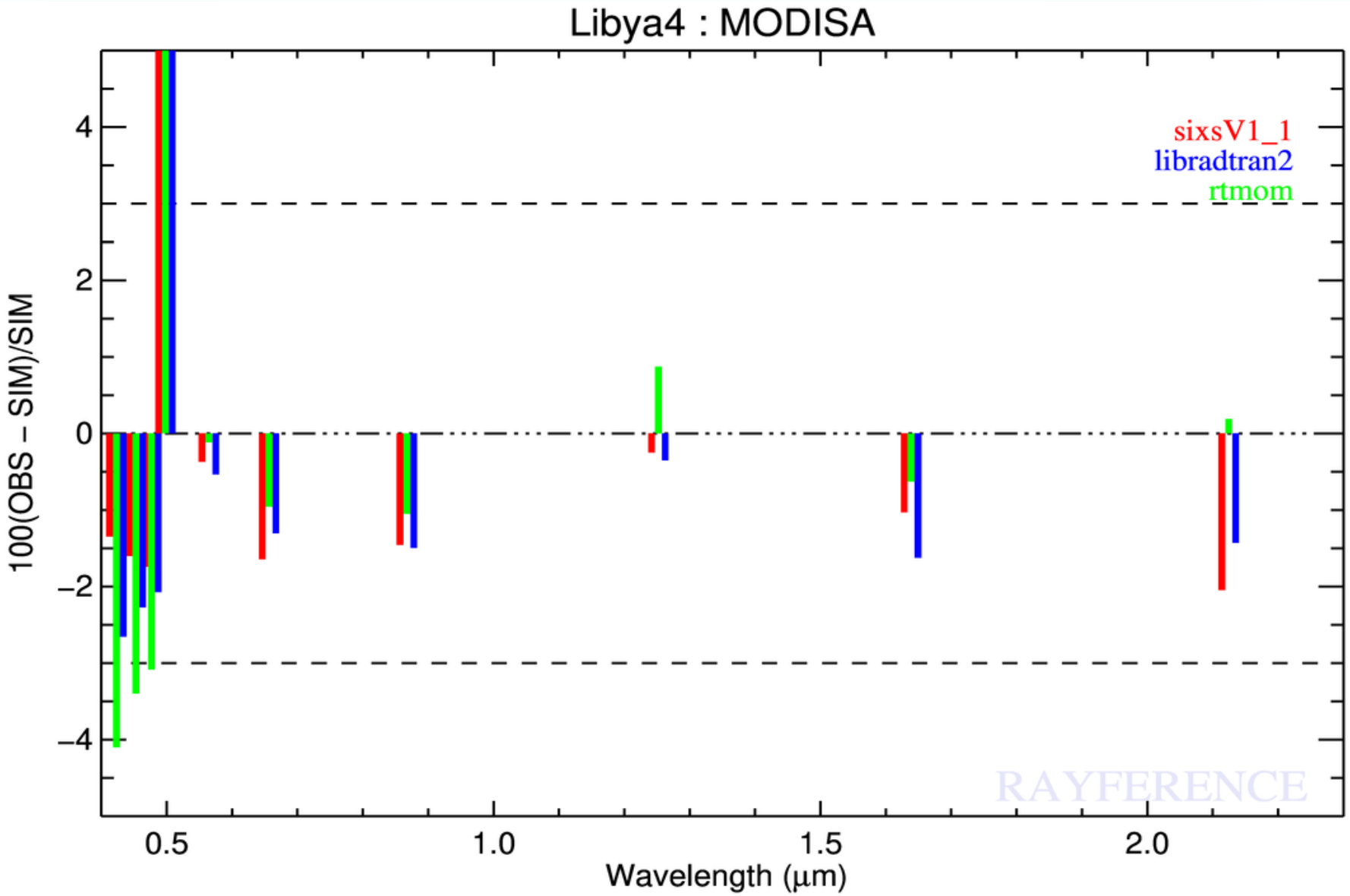
S2A/MSI


Libya4 : S2A_MSI
All SZA values
sixsV1_1
libradtran2
rtmom
100(OBS – SIM)/SIM
4
2
0
–2
–4
0.5
1.0
1.5
2.0
Wavelength (µm)
RAYFERENCE

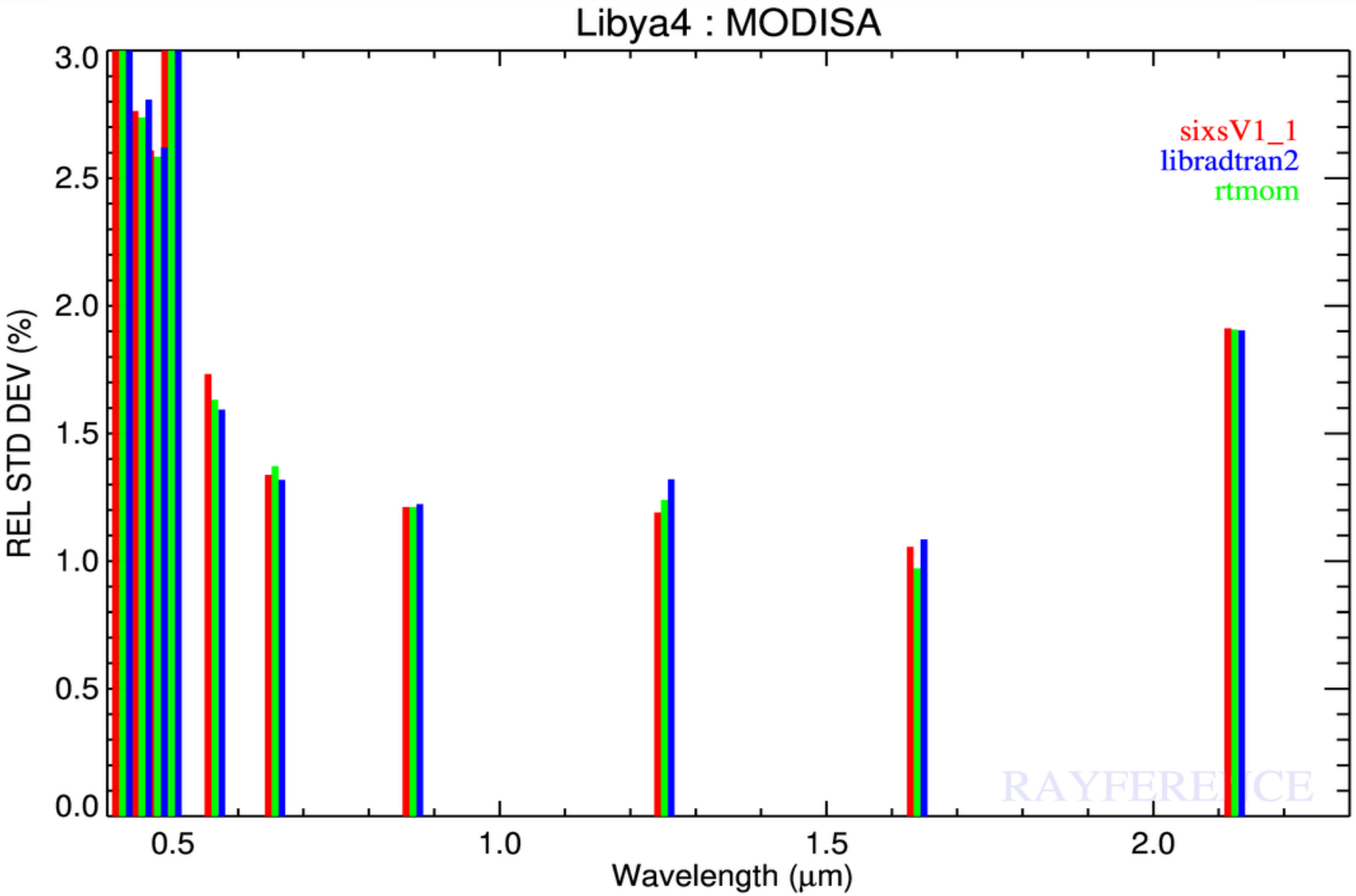
L8/OLI


Libya4 : L8_OLI
sixsV1_1
libradtran2
rtmom
REL STD DEV (%)
Wavelength (µm)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0.5
1.0
1.5
2.0
RAYFERENCE

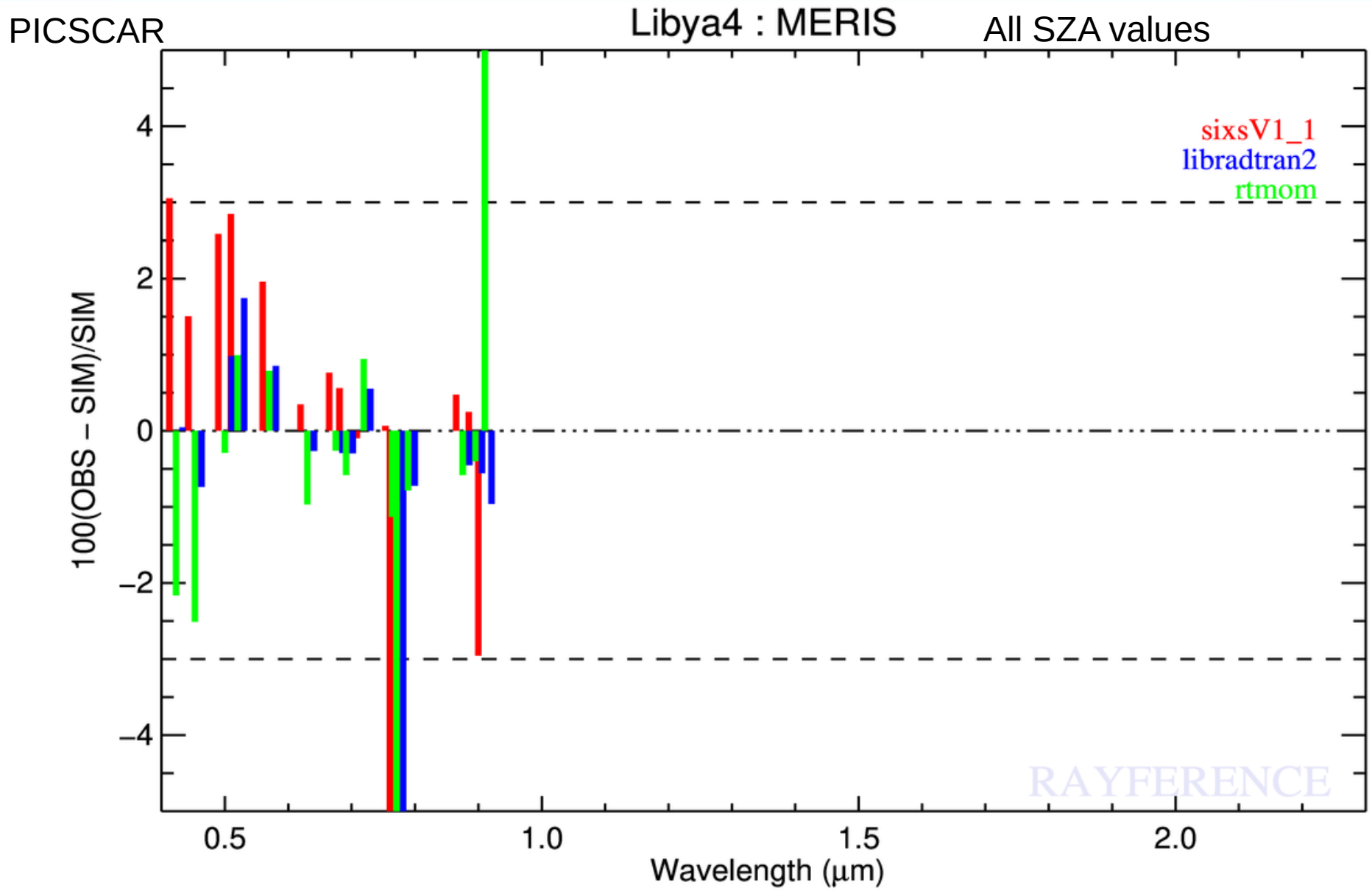
AQUA/MODIS


Libya4 : MODISA
sixsV1_1
libradtran2
rtmom
100(OBS – SIM)/SIM
4
2
0
−2
−4
0.5
1.0
1.5
2.0
Wavelength (µm)
RAYFERENCE

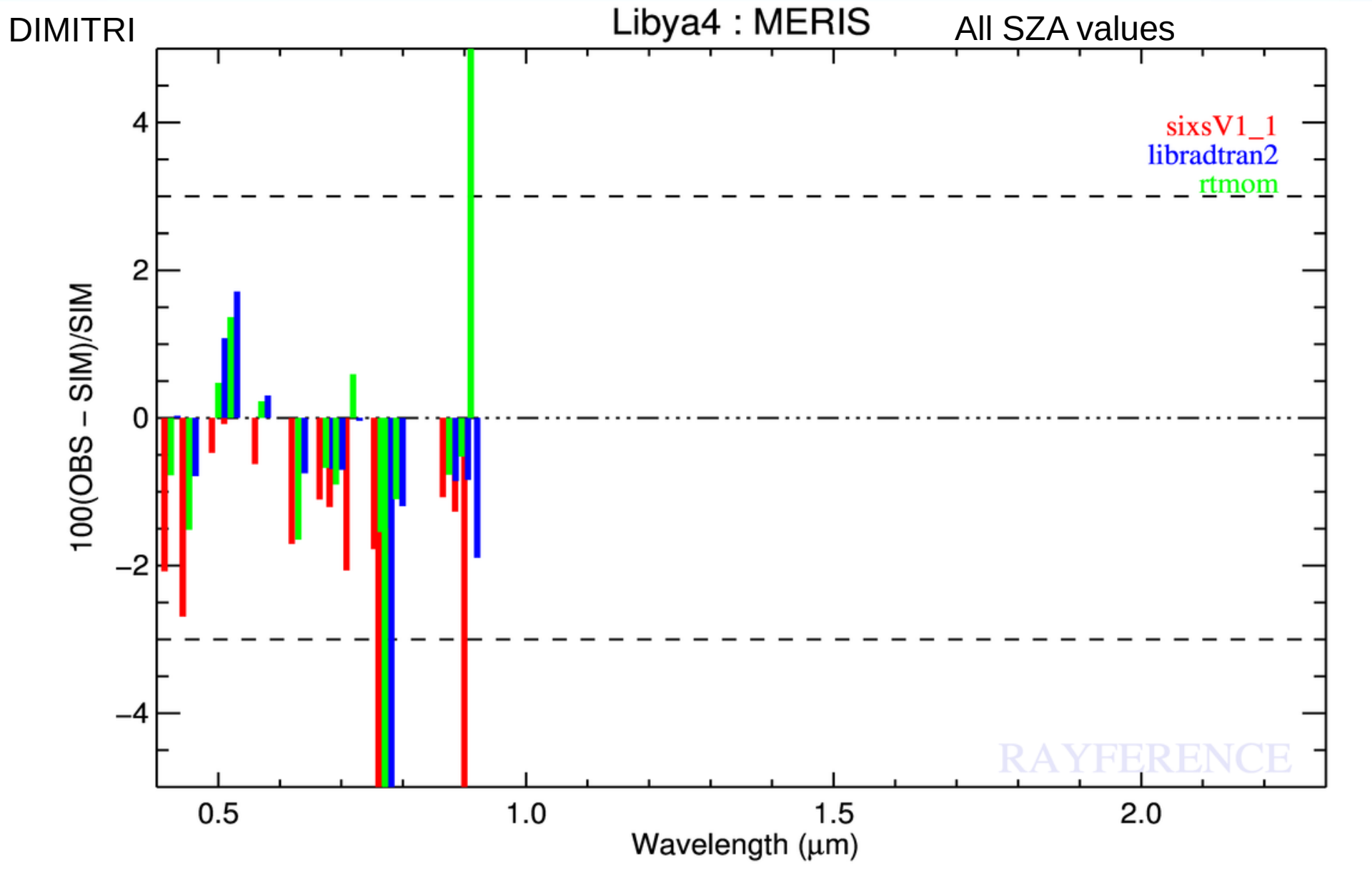
AQUA/MODIS


Libya4 : MODISA
sixsV1_1
libradtran2
rtmom
REL STD DEV (%)
Wavelength (µm)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.5
1.0
1.5
2.0
RAYFERENCE

Envisat/MERIS

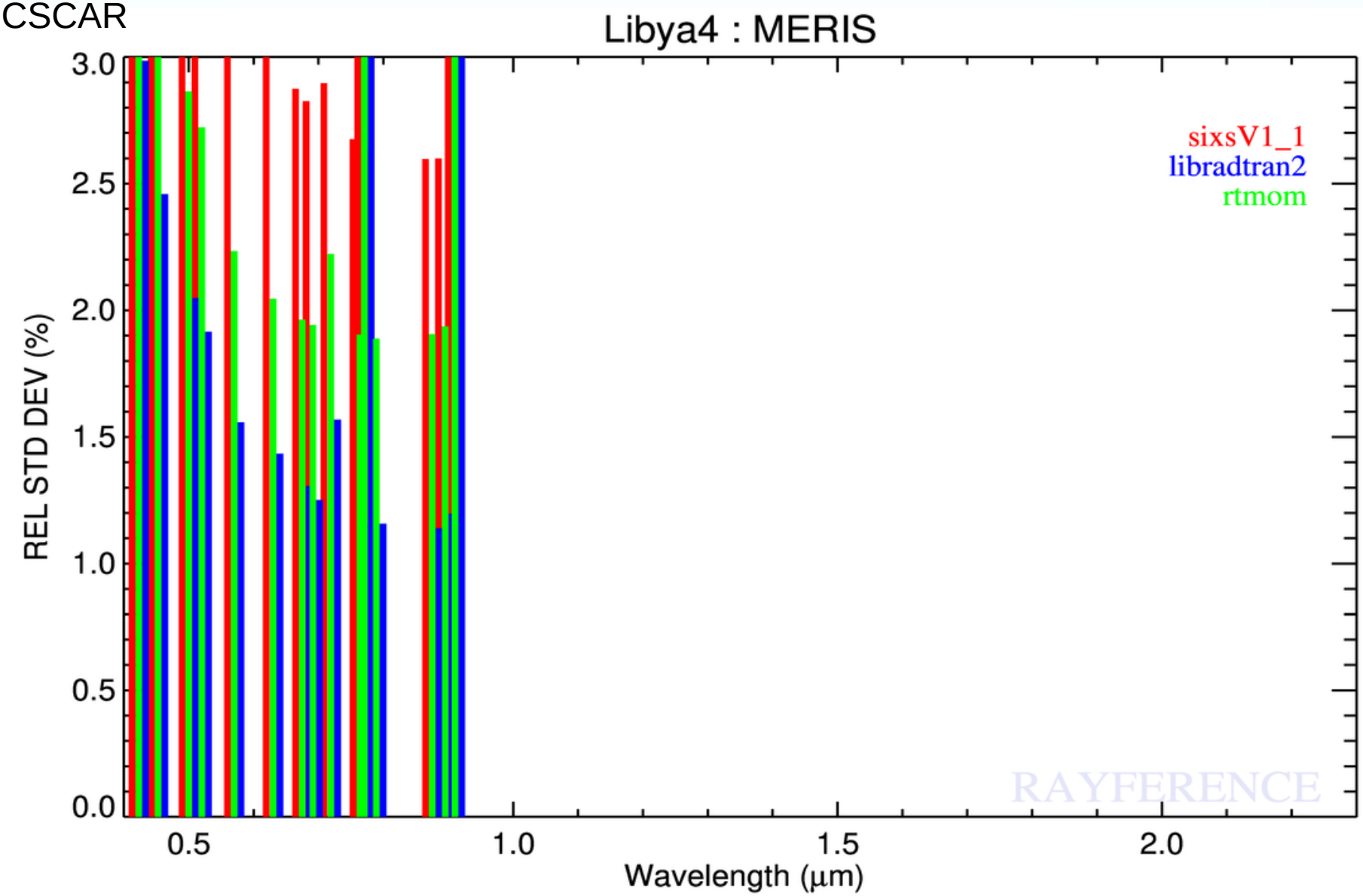


Envisat/MERIS

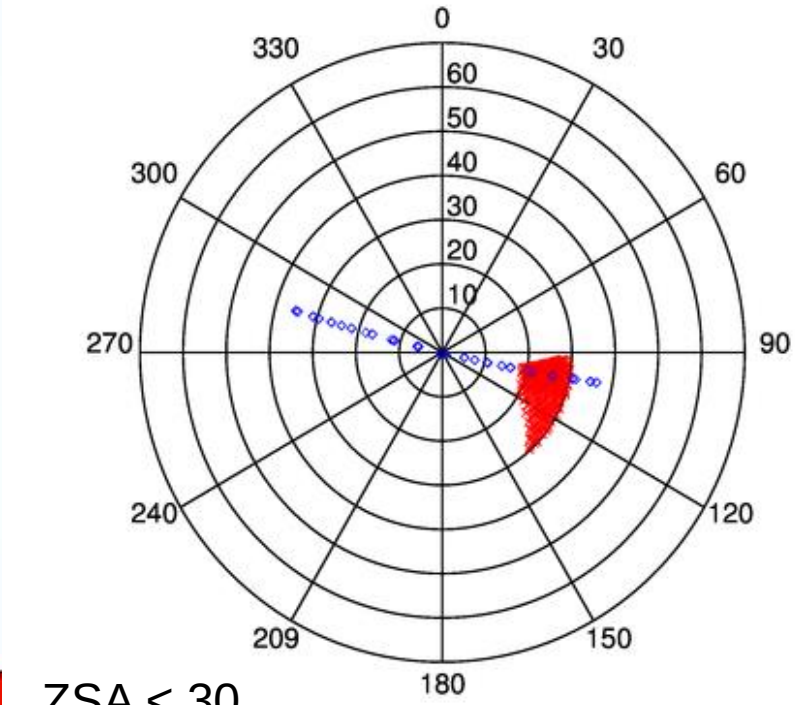


Envisat/MERIS

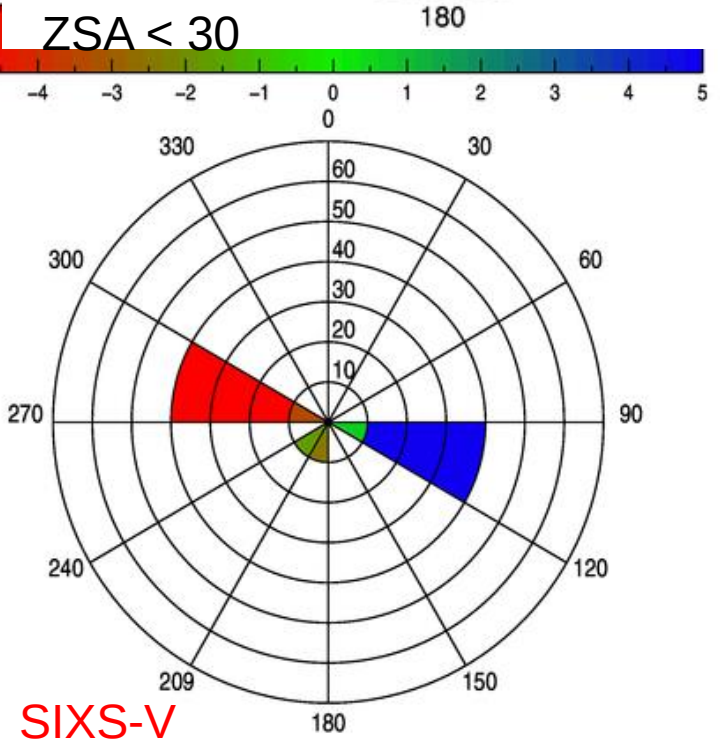
PICSCAR



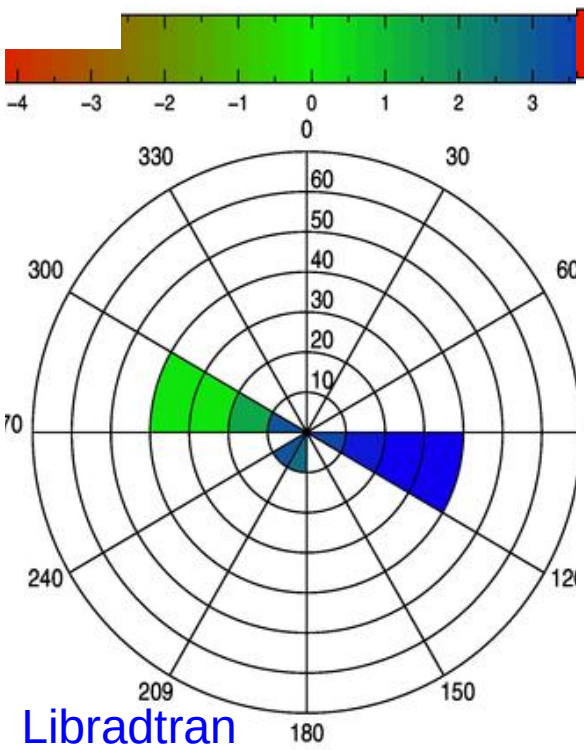
MERIS 412 band



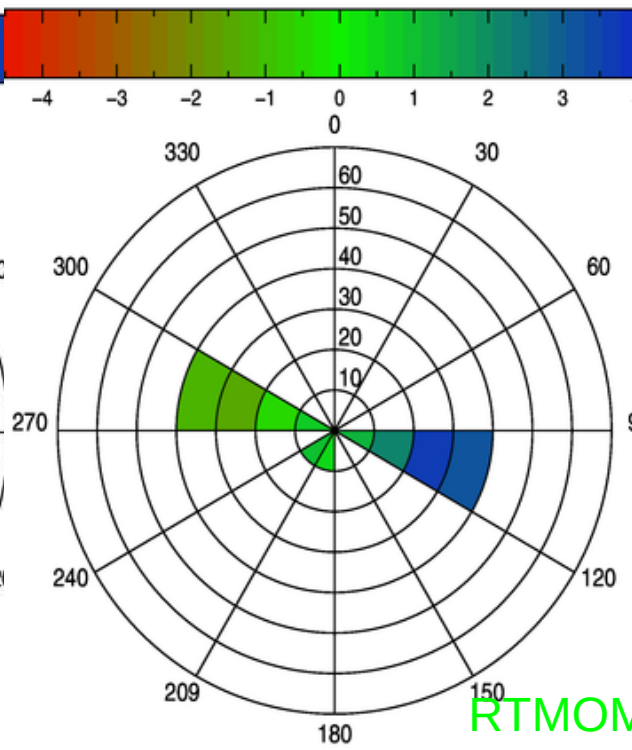
ZSA < 30



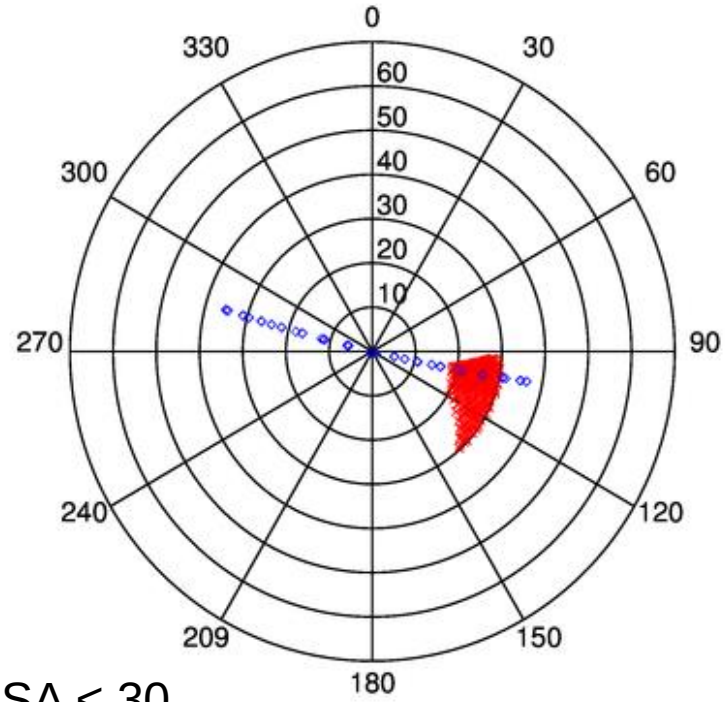
SIXS-V



Libradtran

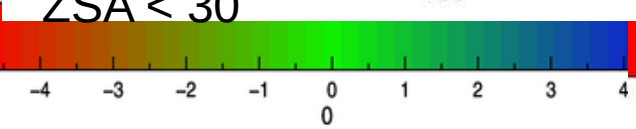


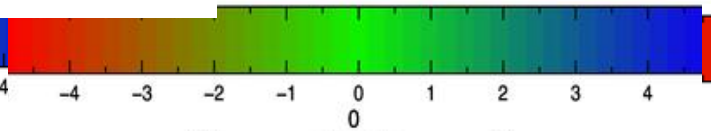
RTMOM

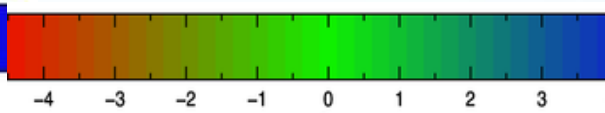


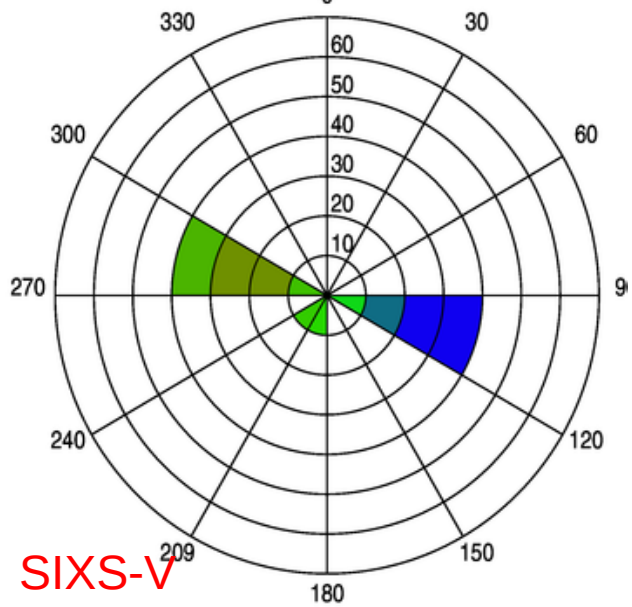
MERIS 885 band

ZSA < 30

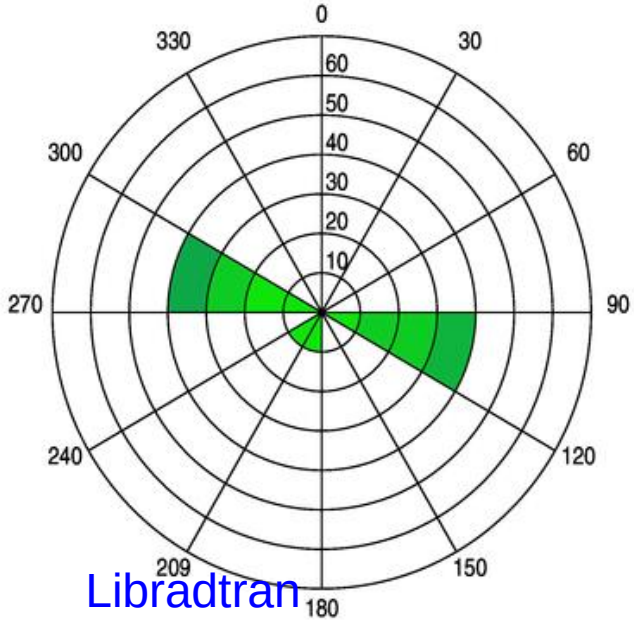




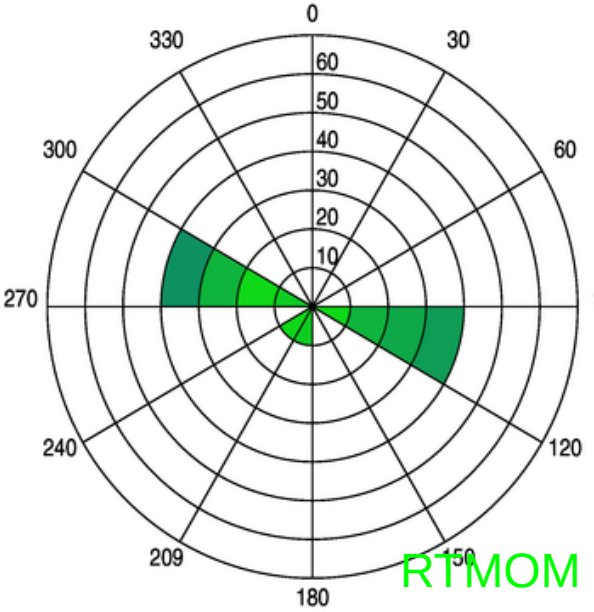




SIXS-V



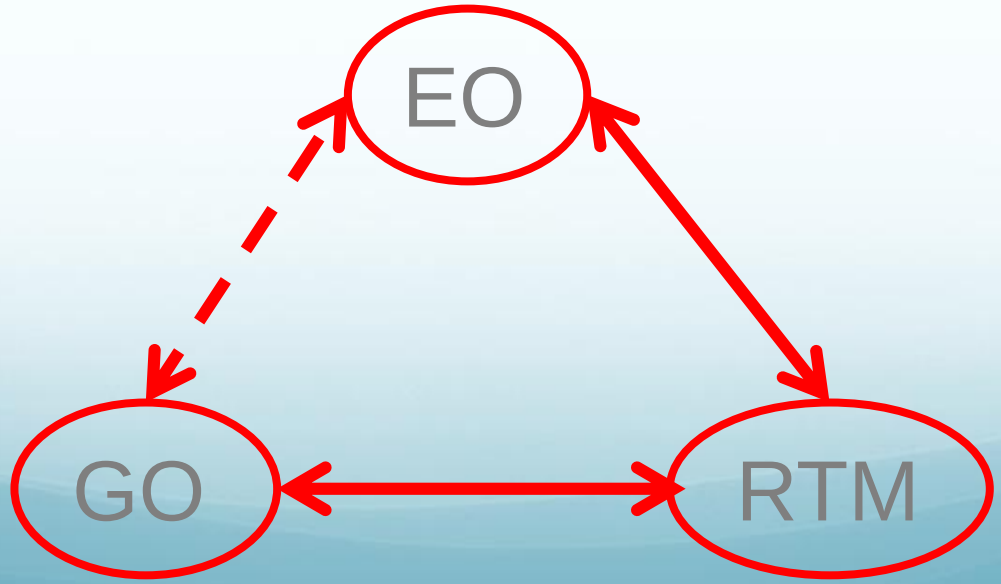
Libradtran



RTMOM

BACKGROUND

- Radiation transfer models (RTM) is the only way to understand EO observations;
- There is a need to have an accurate consistency between ground observations (GO), RTM and EO data.



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TOWARD A 1% RTM ACCURACY

- Surface BRF : accounting for topography (e.g., oriented sand dune);
- Molecular absorption: account for species like O4;
- Rigorous calculation of the coupling between:
  - Surface reflectance and atmosphere scattering;
  - Aerosol scattering and molecular absorption;
- Polarization, non flat earth for large zenith angles;
- Improvement of the surface and atmospheric property characterization;

NEW 3D RTM

- In the Framework of the MetEOC-3 project, Rayference will initiate the design of a new **open-source community 3D RTM** to support CalVal activities;
- This new 3D RTM will include the following main features:
  - Simulation of satellite observations in the VIS, NIR and thermal IR spectral regions;
  - Simulation of ground observations;
  - Simulation of laboratory experiments.

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GENERAL CONCEPT

- Based on the recycling of a state-of-the art Monte Carlo Ray Tracer*;*
- Open source, community model;
- Includes best features of existing 1D and 3D RTMs;
- Includes standard scenes and 3D scene generators;
- Includes water, atmosphere, snow, ice, …;
- Extensively evaluated with rigorous protocols.

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PHYSICAL PROCESSES

Possible new features might include

- Polarization;
- Thermal emission;
- Propagation of the phase (coherent back scattering);
- Inelastic scattering (fluorescence, Raman scattering);
- Specific instruments (not BRF at the infinity);
- ….

REQUIREMENTS

- Physical processes to be simulated;
- Scene types (atmosphere, surface, water, ice, …);
- MMI (levels according to applications and users);
- Interface with existing models, data-base.
- Measurement types;
- Expected accuracy;
- Validation protocol.

If interested, please contact vincent.leroy@rayference.eu

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MILESTONES

- A first beta version of this new 3D RTM is expected to be released in 2020 with the core functionalities implemented;
- A limited series of test/demonstration cases (targets) will be developed during that phase;
- The code will be available for contribution in 2021;
- Expected to be fully developed, documented and validated in early 2022.

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CONCLUDING REMARKS

- Feedback from this community for the requirements is welcome (vincent.leroy@rayference.eu);
- There is an opportunity to include a 3D characterization of a CEOS PICS or RadCalNet target;
- Targeted accuracy around 1%.

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