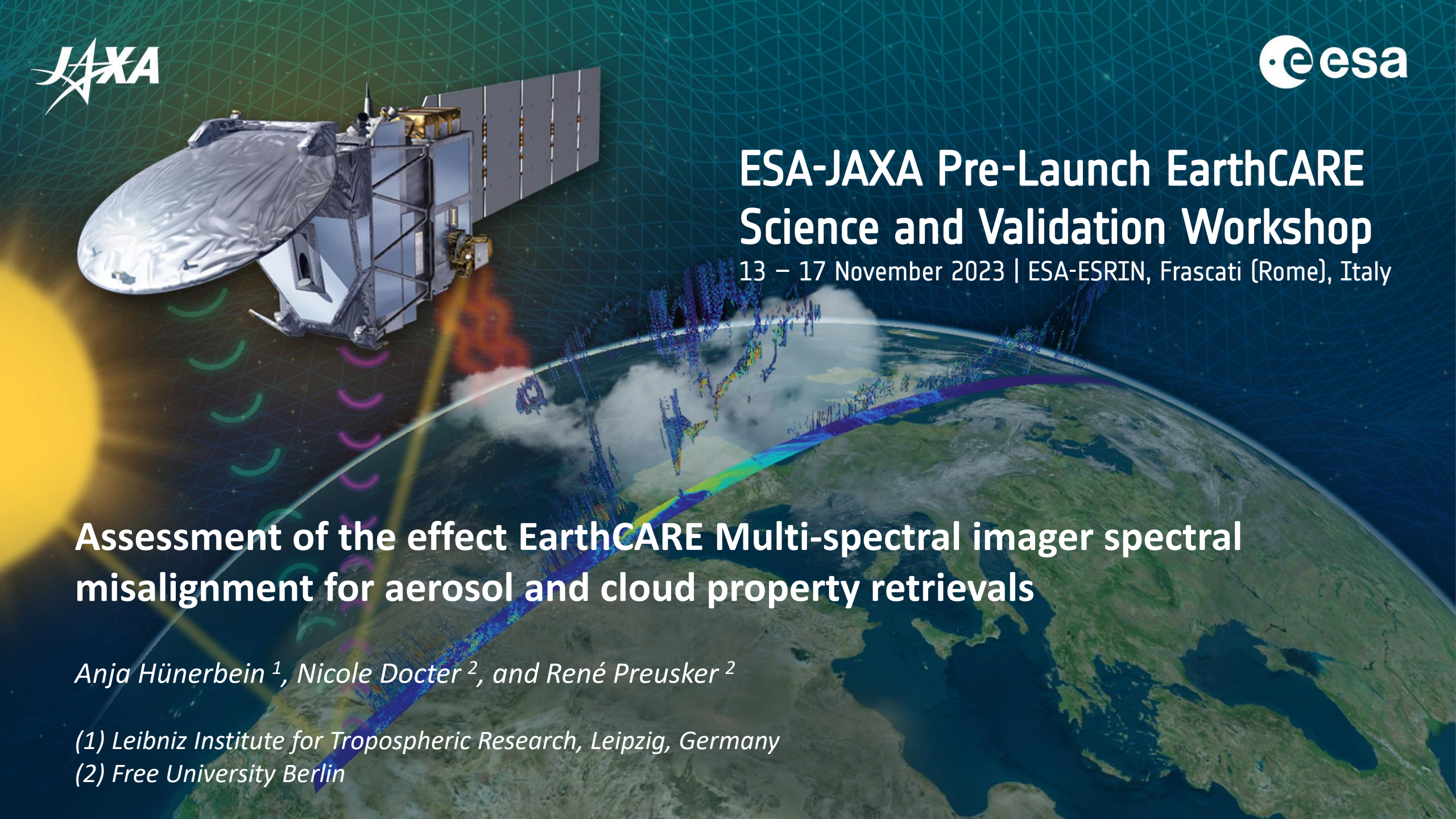

ESA-JAXA Pre-Launch EarthCARE Science and Validation Workshop

13 – 17 November 2023 | ESA-ESRIN, Frascati (Rome), Italy

Assessment of the effect EarthCARE Multi-spectral imager spectral misalignment for aerosol and cloud property retrievals

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Content

- Introduction MSI spectral misalignment
- Spectral forward simulation:
  - Gas transmission
  - Surface description
  - Aerosol and cloud properties
- Error quantification on the MSI L2 aerosol and cloud product
  - MSI smile scene

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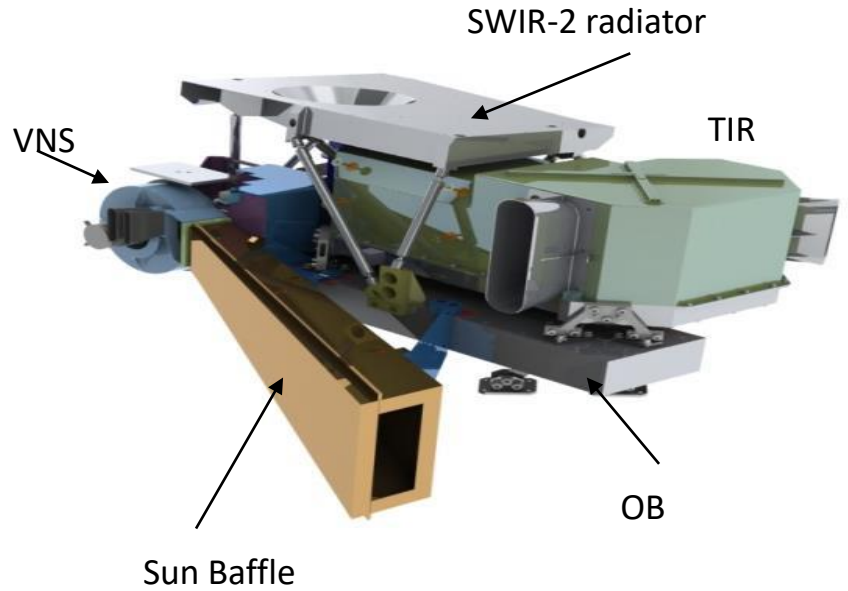
Introduction MSI spectral misalignment

Multi-Spectral Imager (MSI):

Channel	Center Wavelength µm	Bandwidth (50%)
VIS	0.67	20 nm
NIR	0.865	20 nm
SWIR-1	1.65	50 nm
SWIR-2	2.21	0.1 µm
TIR 1	8.80	0.9 µm
TIR 2	10.80	0.9 µm
TIR 3	12.00	0.9 µm



Determination of cloud and aerosol properties and horizontal structures of clouds

⇨ baseline-products comparable to MODIS products (follow-on A-Train)

- cloud cover and cloud phase
- cloud optical and physical properties
- aerosol properties

⇨ synergy with active instruments

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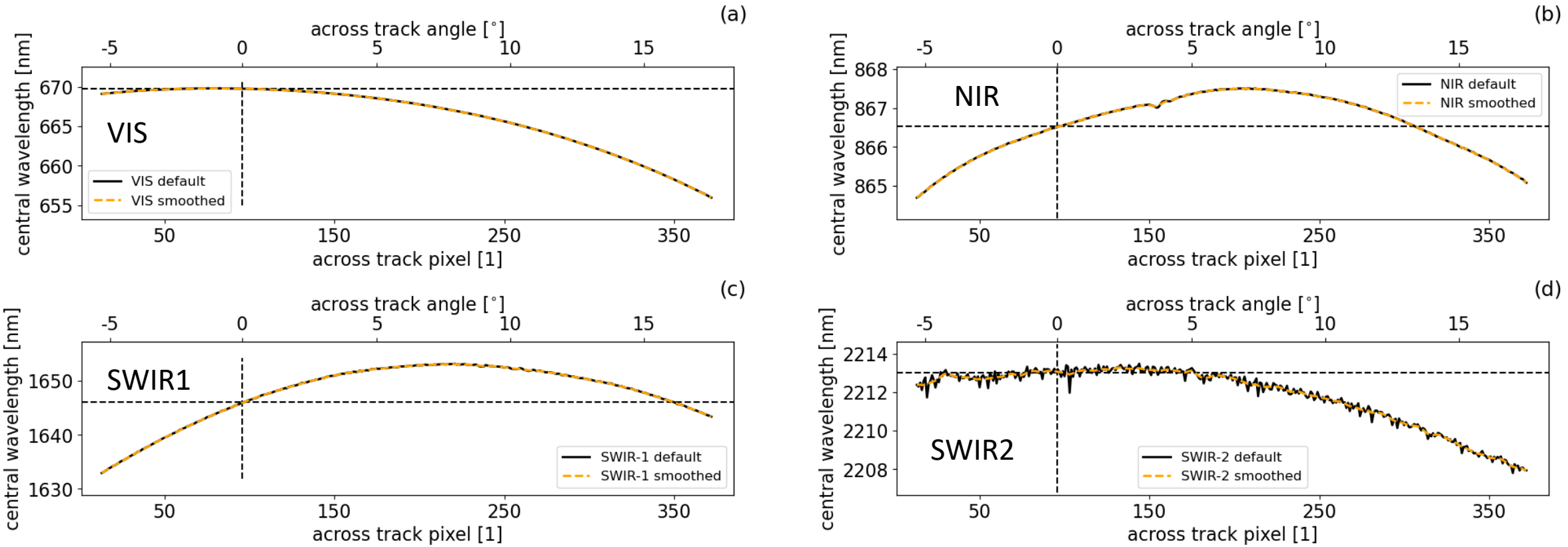
Introduction MSI spectral misalignment



- Central wavelength are calculated from the filter function

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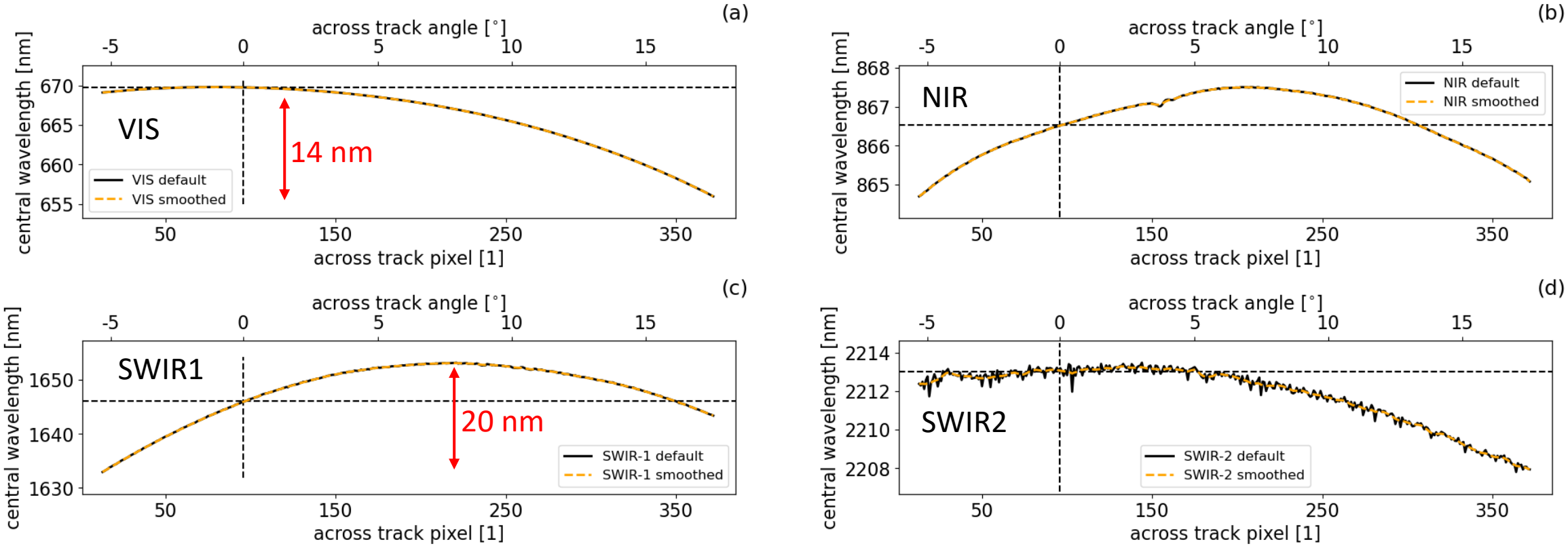
Introduction MSI spectral misalignment



- Spectral forward simulation based on radiative transfer model :
  - Gas transmission
  - Surface description
  - Aerosol and cloud properties

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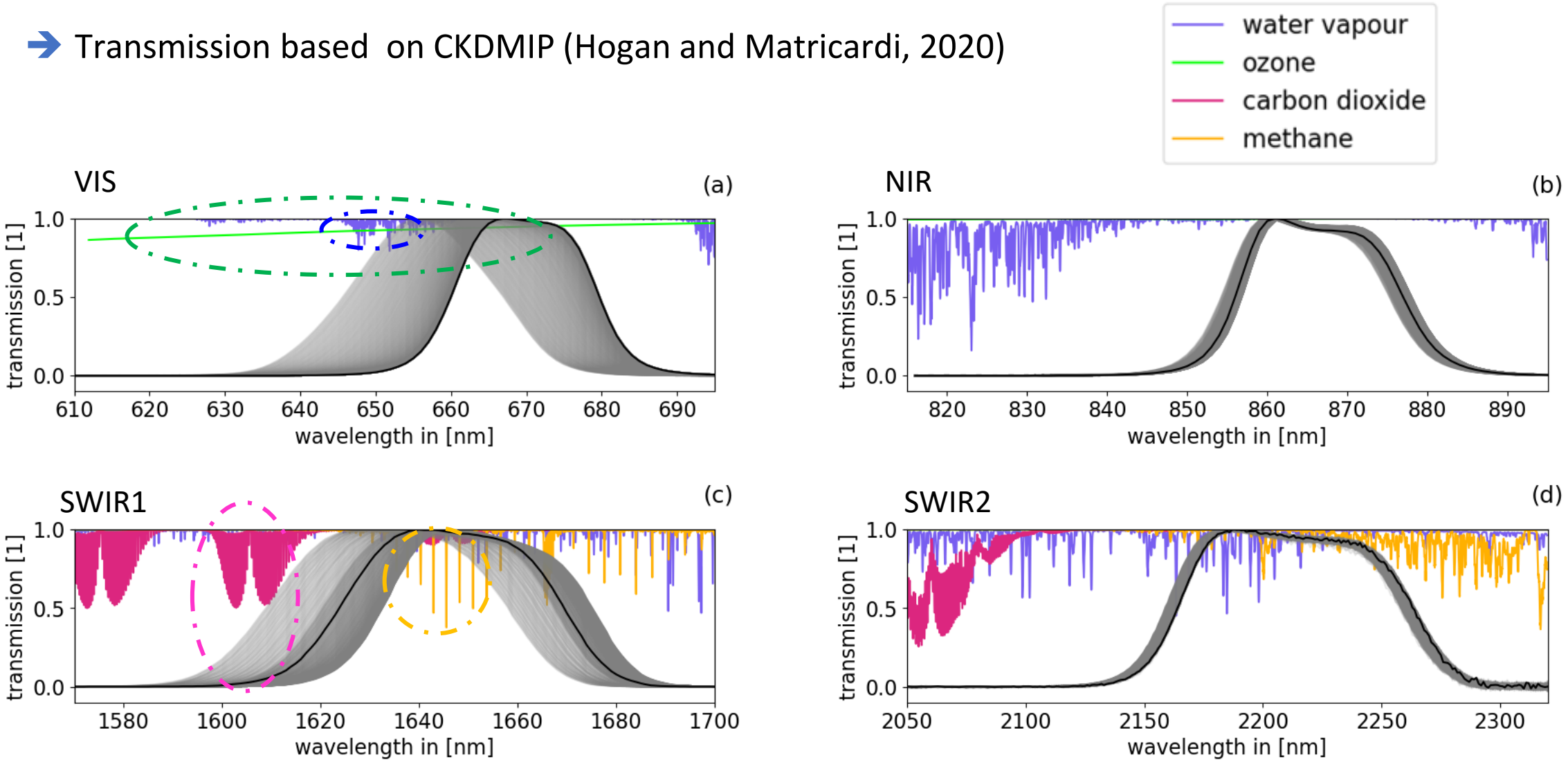
MSI smile effect on gaseous absorption

➔ Transmission based on CKDMIP (Hogan and Matricardi, 2020)



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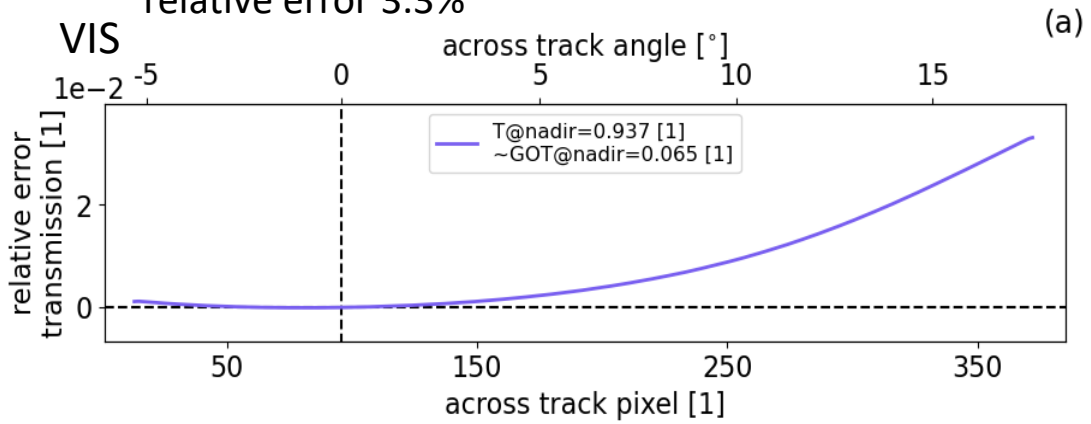
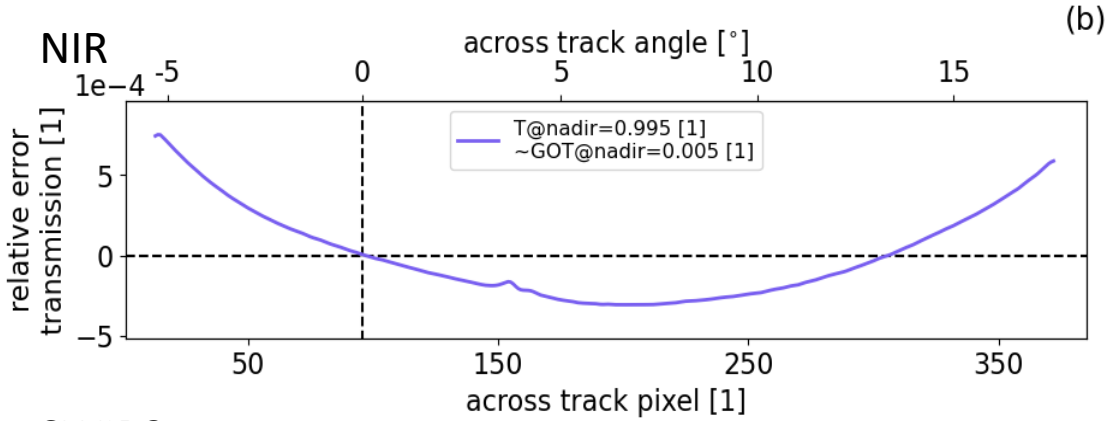
MSI smile effect on gaseous absorption

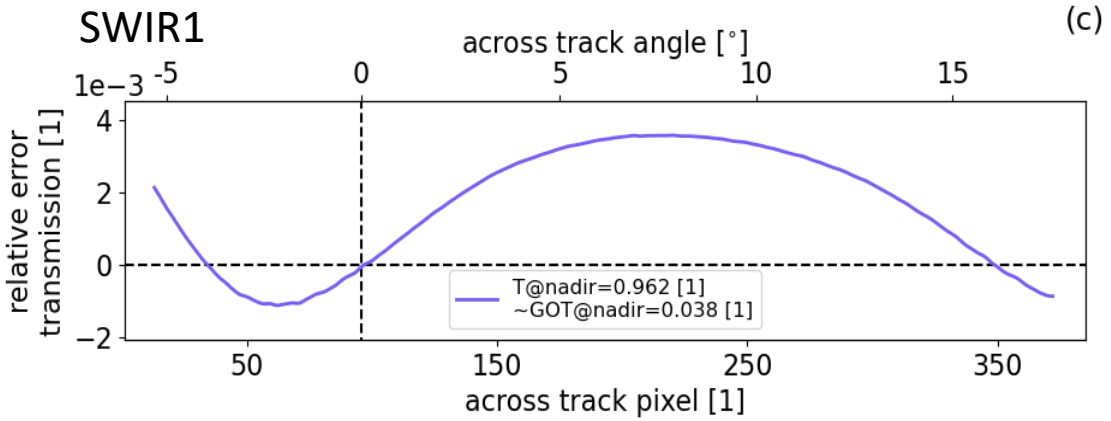
Relative error on normalized TOA radiance:

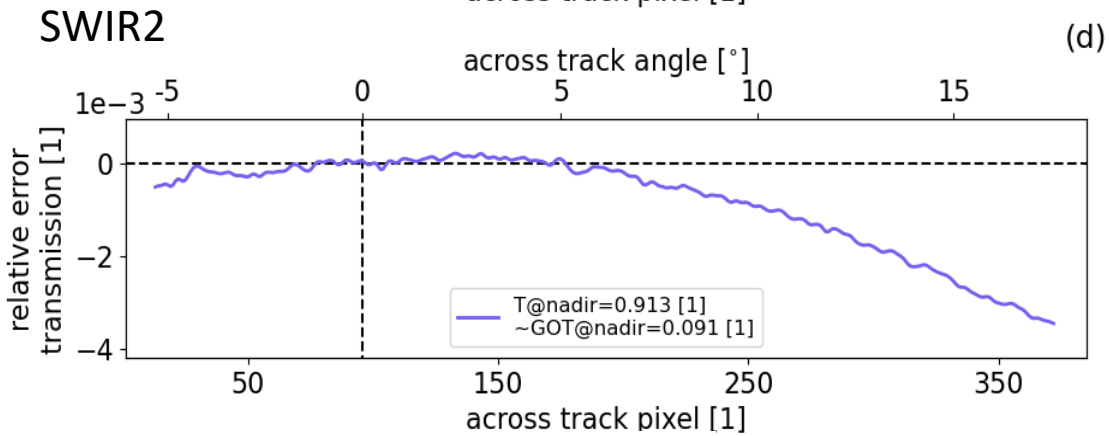
$$\delta x = \frac{x_{nadir} - x_{true}}{x_{true}}$$

absorption of ozone and water vapour
relative error 3.3%









absorption of methane and carbon dioxide
relative error -0.1 to 0.3%

relative error below +/-0.5%

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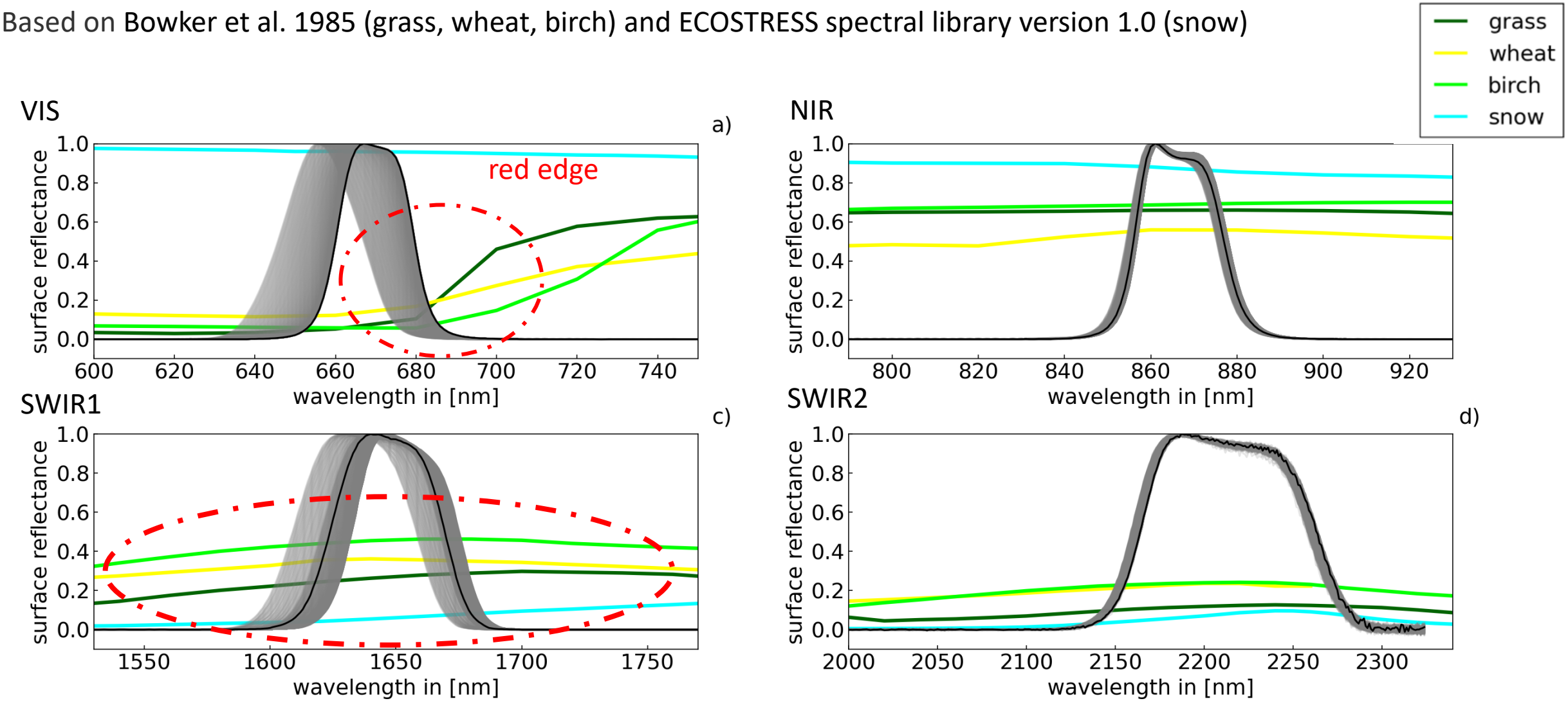
MSI smile effect on surface description

Based on Bowker et al. 1985 (grass, wheat, birch) and ECOSTRESS spectral library version 1.0 (snow)



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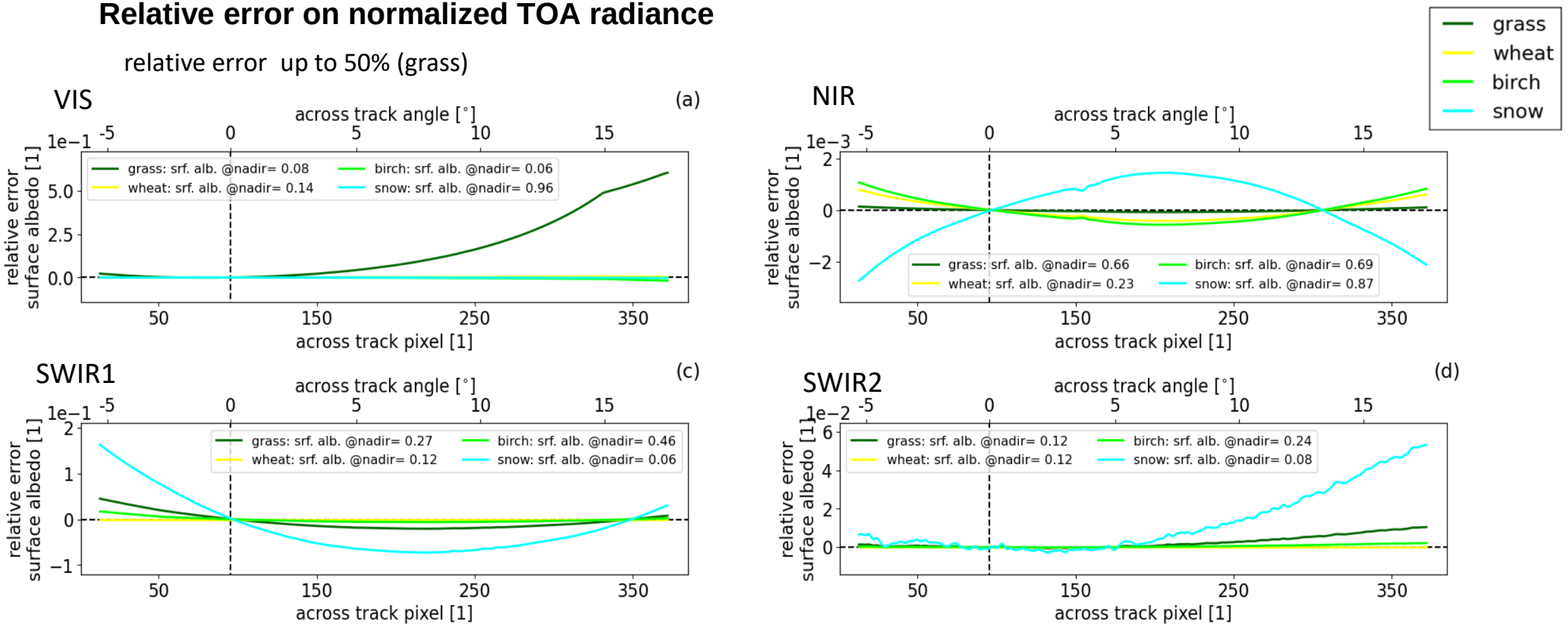
MSI smile effect on surface description

Relative error on normalized TOA radiance

relative error up to 50% (grass)



relative error varies between
-7.3% and 16.3% (snow), -2.1% and 4.5% (grass)

relative error is about
1% (grass) and up 5.3% (snow)

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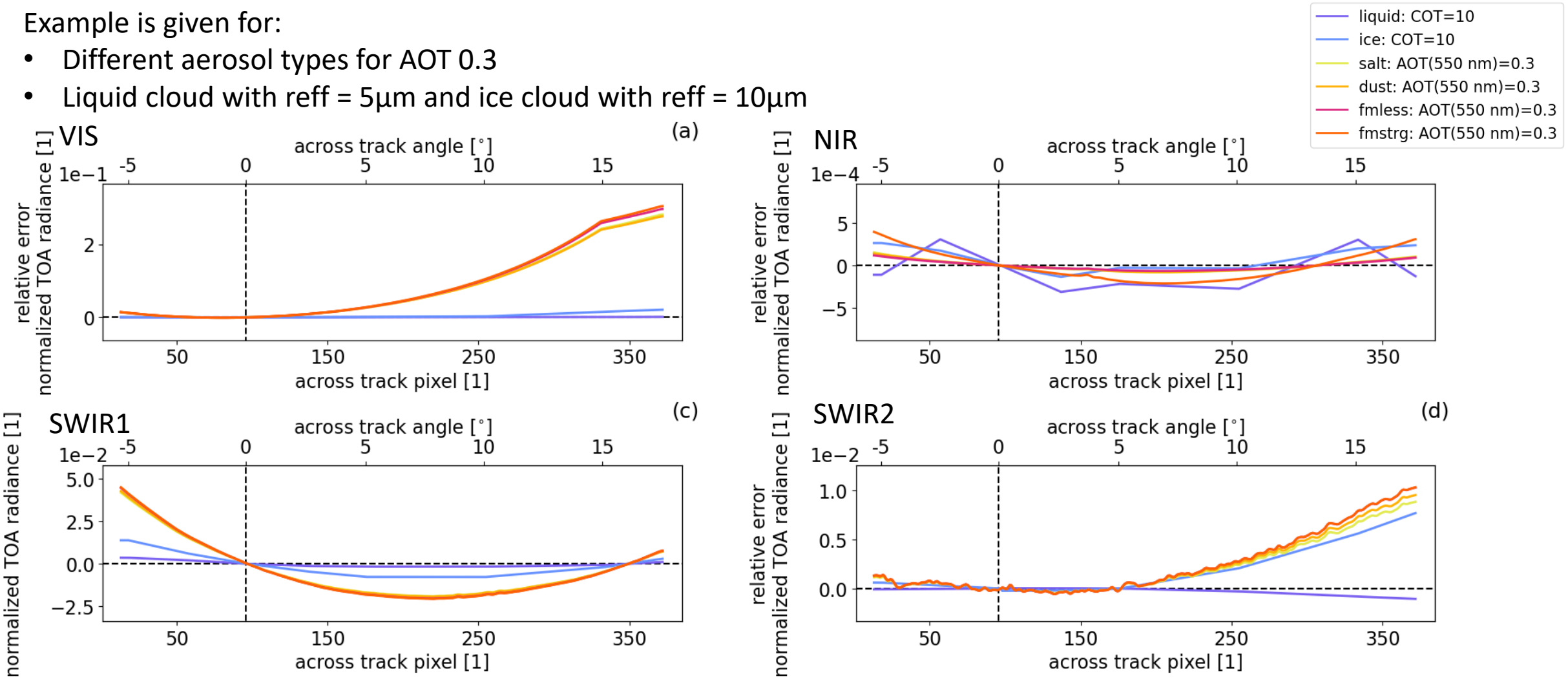
Impact aerosol and cloud properties

Example is given for:

- Different aerosol types for AOT 0.3
- Liquid cloud with reff = 5µm and ice cloud with reff = 10µm



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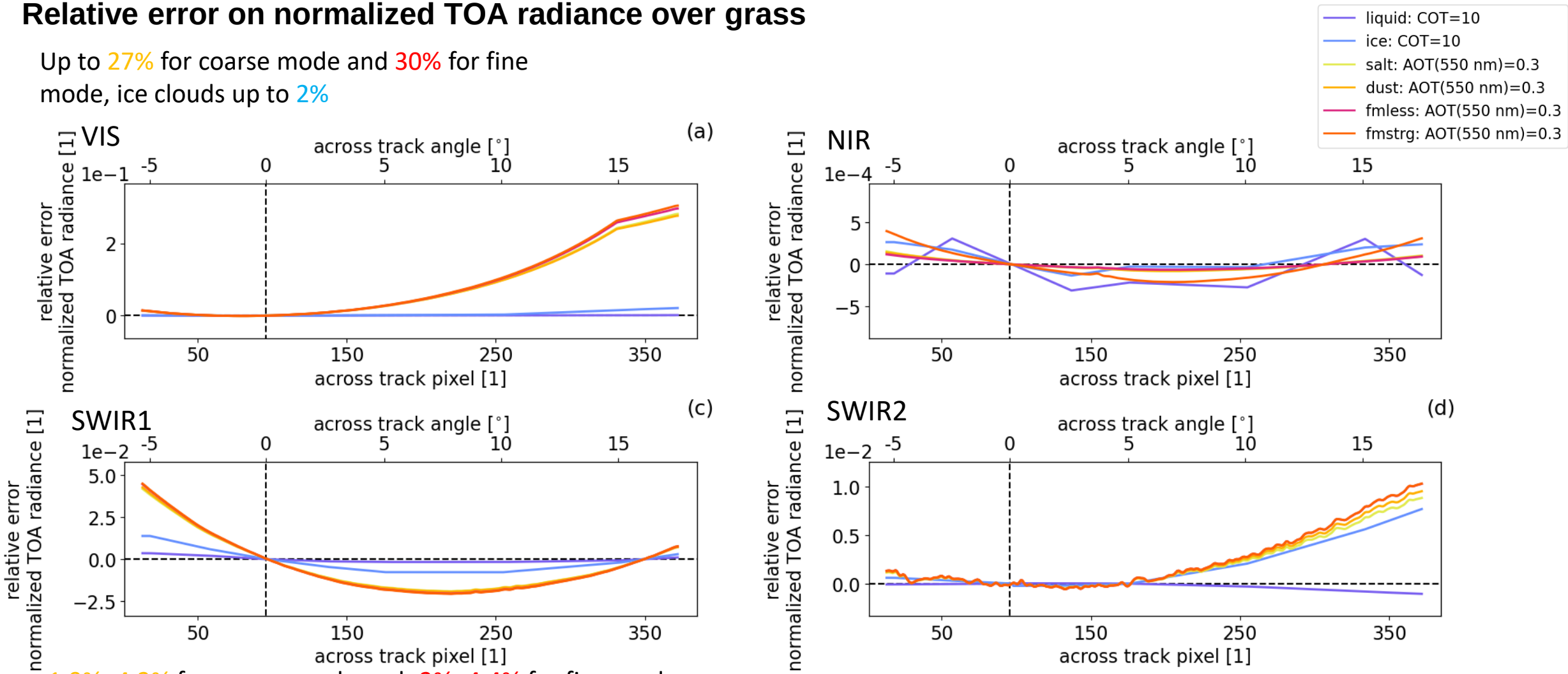
Impact aerosol and cloud properties

Relative error on normalized TOA radiance over grass

Up to 27% for coarse mode and 30% for fine mode, ice clouds up to 2%



-1.9%- 4.2% for coarse mode and -2%- 4.4% for fine mode, ice clouds 1.4%- -0,8%

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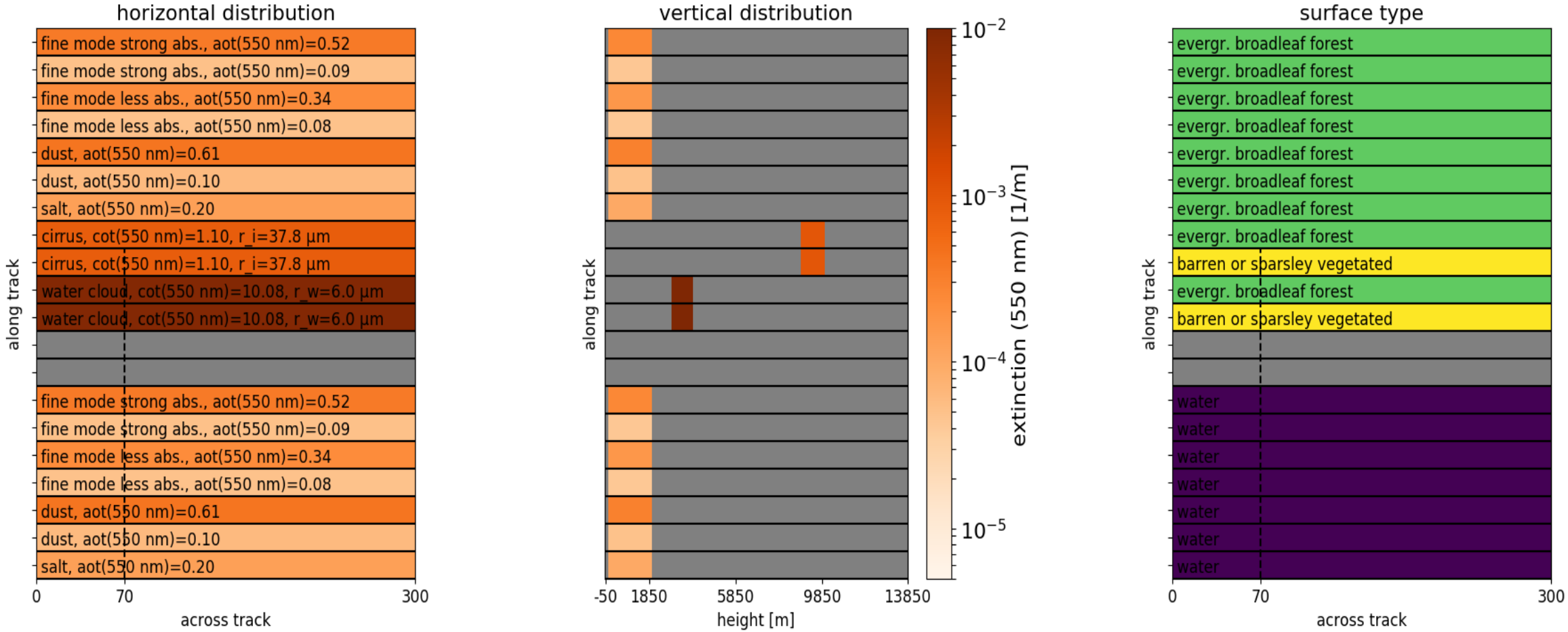
Error quantification for MSI L2 product

Synthetic MSI smile block scene with the EarthCARE simulator (Donovan et al. 2023)



Two ECSIM runs: 1. Ideal condition

2. Contains the SMILE affected quantities as surface, gas, aerosol and cloud properties

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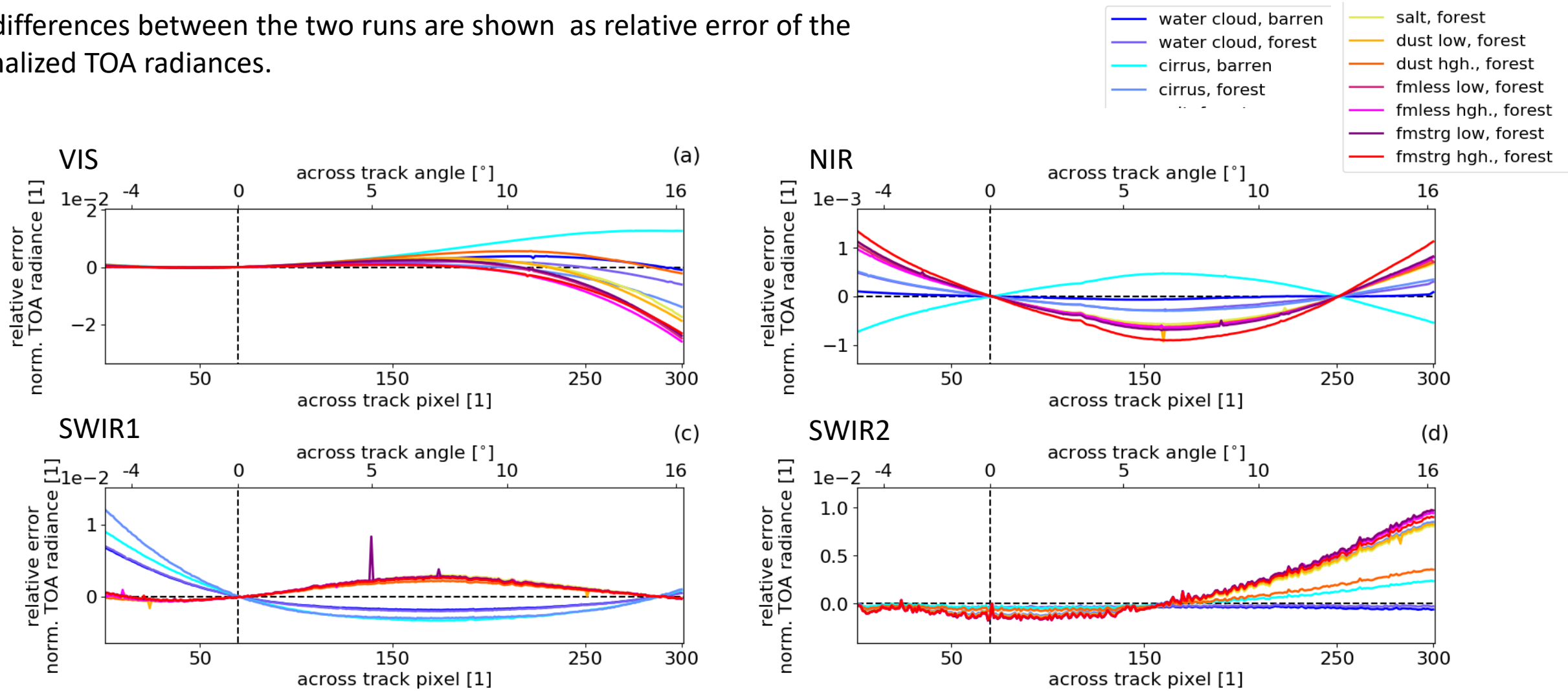
Error quantification for MSI L2 product

The differences between the two runs are shown as relative error of the normalized TOA radiances.



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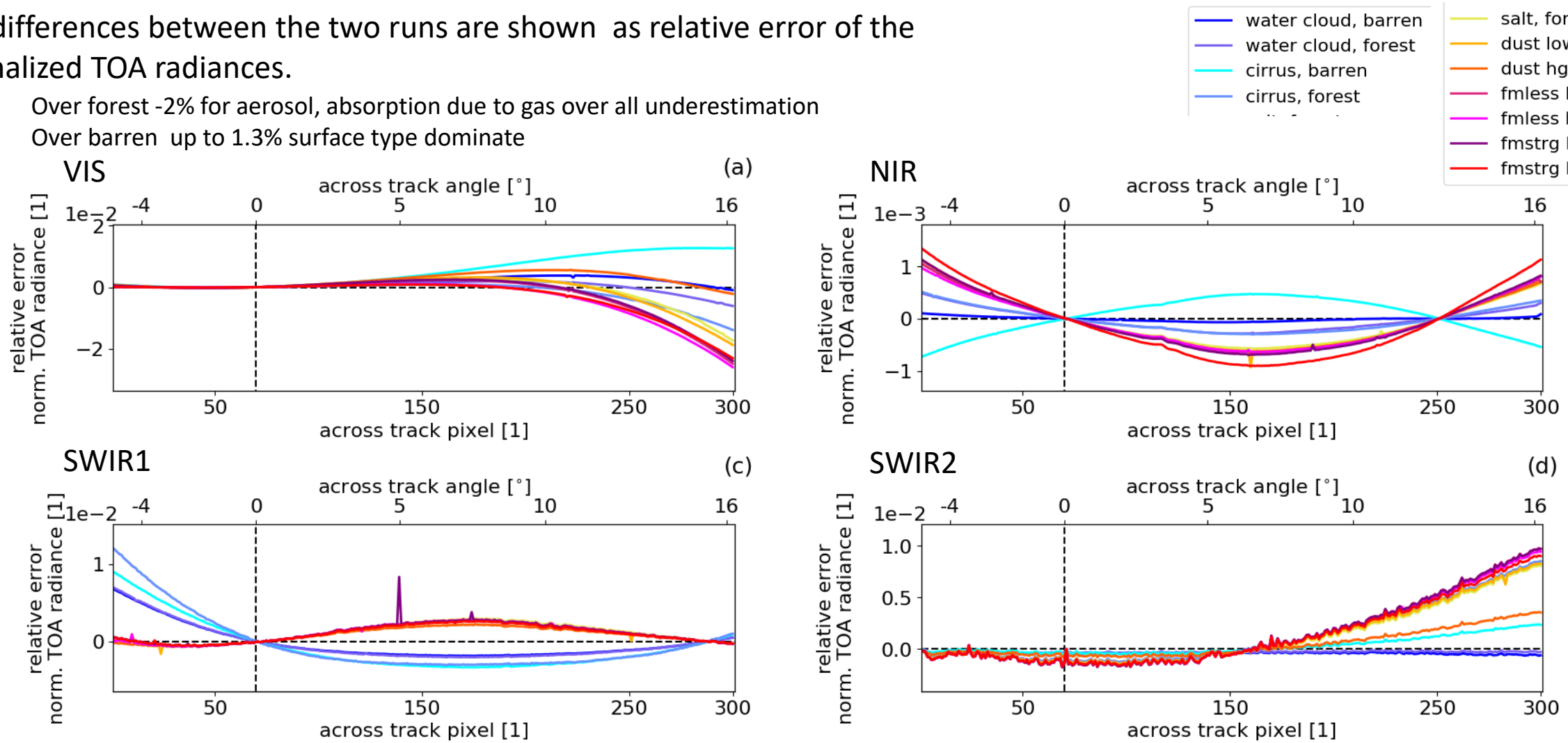
Error quantification for MSI L2 product

The differences between the two runs are shown as relative error of the normalized TOA radiances.

Over forest -2% for aerosol, absorption due to gas over all underestimation

Over barren up to 1.3% surface type dominate



Cirrus: 1.3% forest, barren surface cloud (single scattering albedo place a role)

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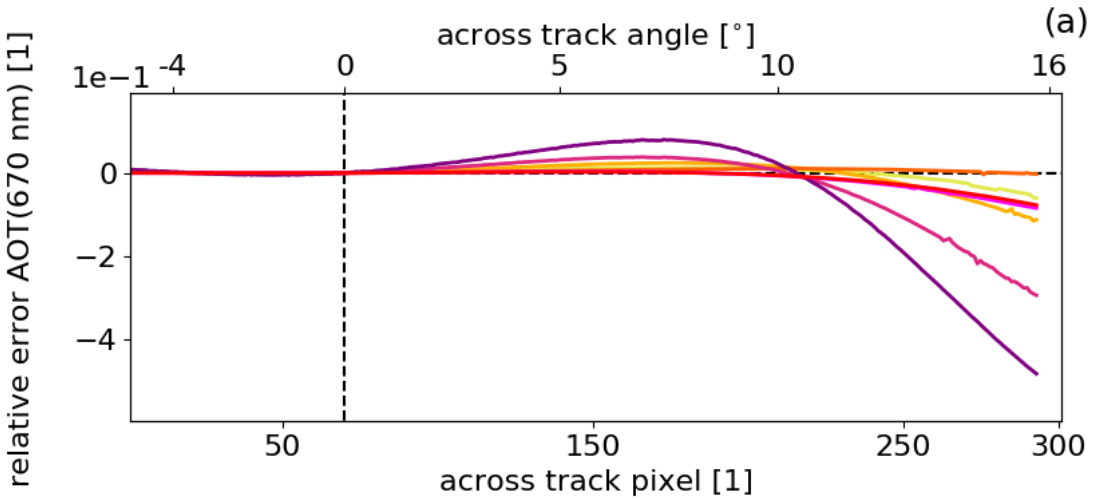
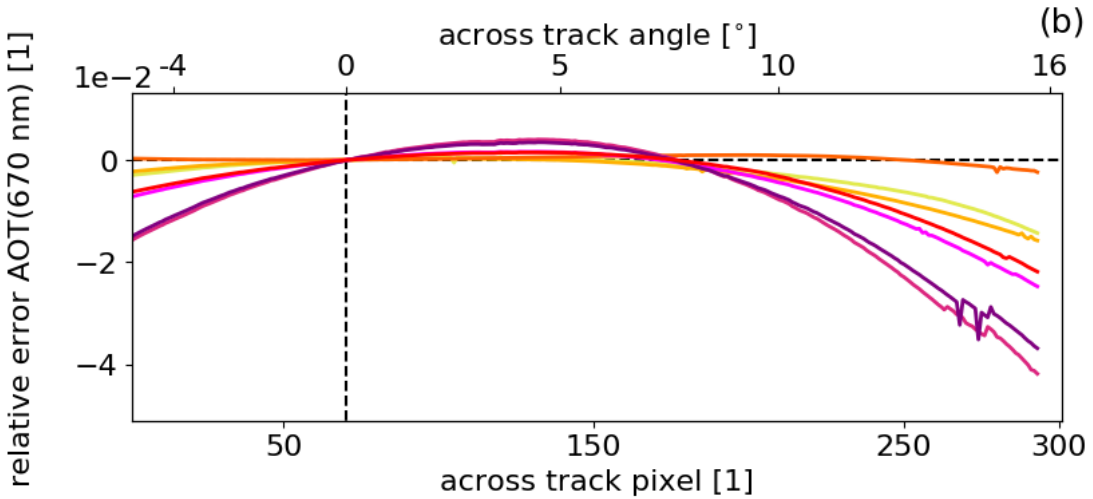
Error quantification for MSI L2 product

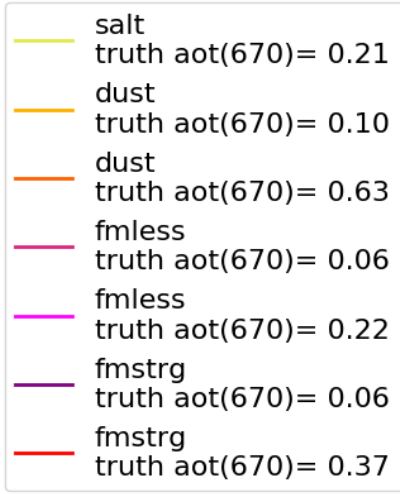
Over land



Over ocean



- AOT at 670nm is highest -48% fine mode strong absorbing
- AOT at 670nm over land underestimated up to -30% fine mode less absorbing
- Error decrease for higher AOT loading and bigger particles (dust)



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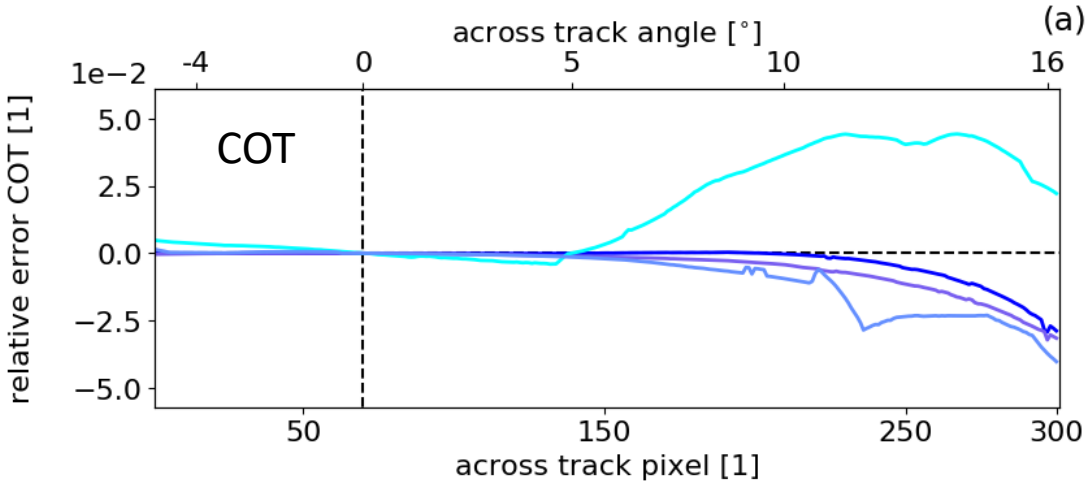
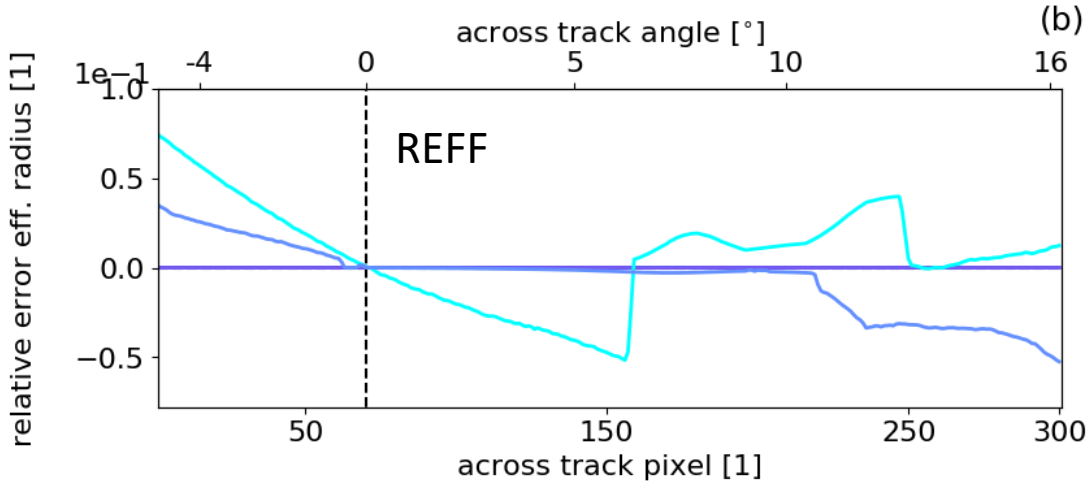
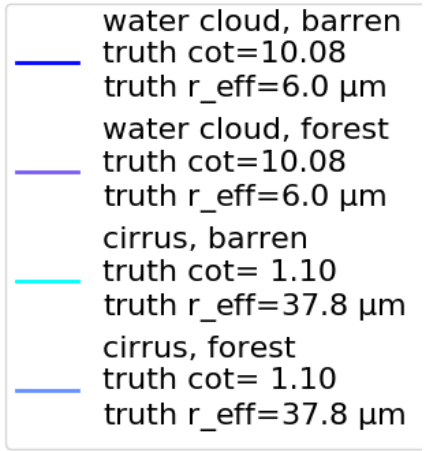
Error quantification for MSI L2 product

Over land







- Cloud dominated by the surface properties for optical thin clouds stratocumulus still up to -3 %
- Cloud effective radius with small effective radius is smaller but with higher cloud effective radius error from 7.5% up to -5%

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Conclusion

MSI spectral misalignment:

- MSI shows a cross track central wavelength variation in VIS and SWIR channel of up to 14 and 20 nm
- For low optical thickness of aerosol and cloud (less than 8) we found significant error caused by gas absorption, surfaces as well as cloud properties
- Measured Level 1 signal is not planned to be corrected,
  but the Level 2 retrieval M-AOT (Docter et al. 2023) and M-CLD (Hünerbein et al. 2023) will adapt the look up tables: for gas correction coefficients, surface parameterization coefficients, aerosol and cloud

  see more -> Docter et al, 2023 in the special issue of EarthCARE in AMT

- Thanks to the RTTOV team the TIR coefficients are calculated and available now

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