The European Anthropogenic CO_2 Monitoring Mission: Instrument spectral sizing and the supporting aerosol instrument

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Low versus High Spectral Resolution Concept

High resolution case (HR) reflects OCO-2 spectral sizing.
Moderate resolution case (MR) is based on CarbonSat heritage.

	NIR		SW1		SW2	
	band width	resolution	band width	resolution	band width	resolution
HR	758-772 nm	0.042 nm	1591-1621 nm	0.076 nm	2042-2081 nm	0.097 nm
MR	747-773 nm	0.1 nm	1590-1675 nm	0.3 nm	1925-2095 nm	0.55 nm

SNR performance is derived for a realistic instrument concept depending on spectral sizing.

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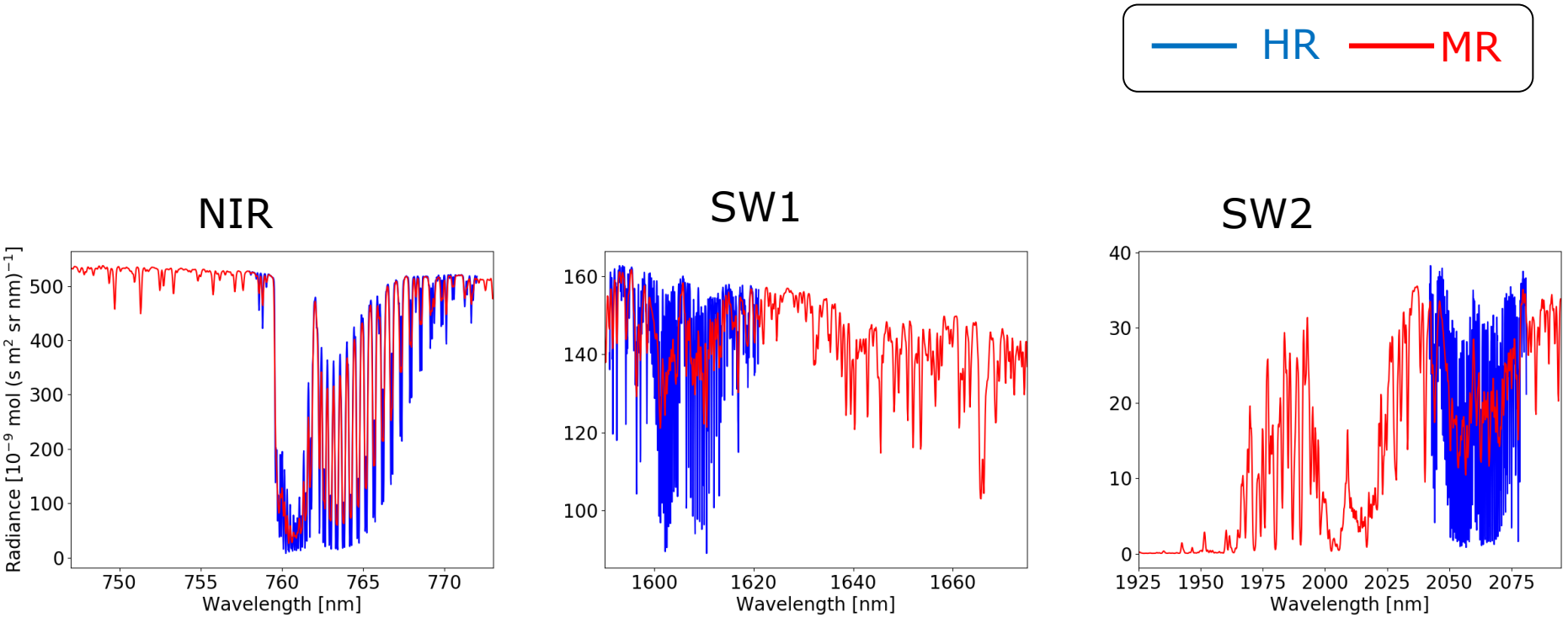
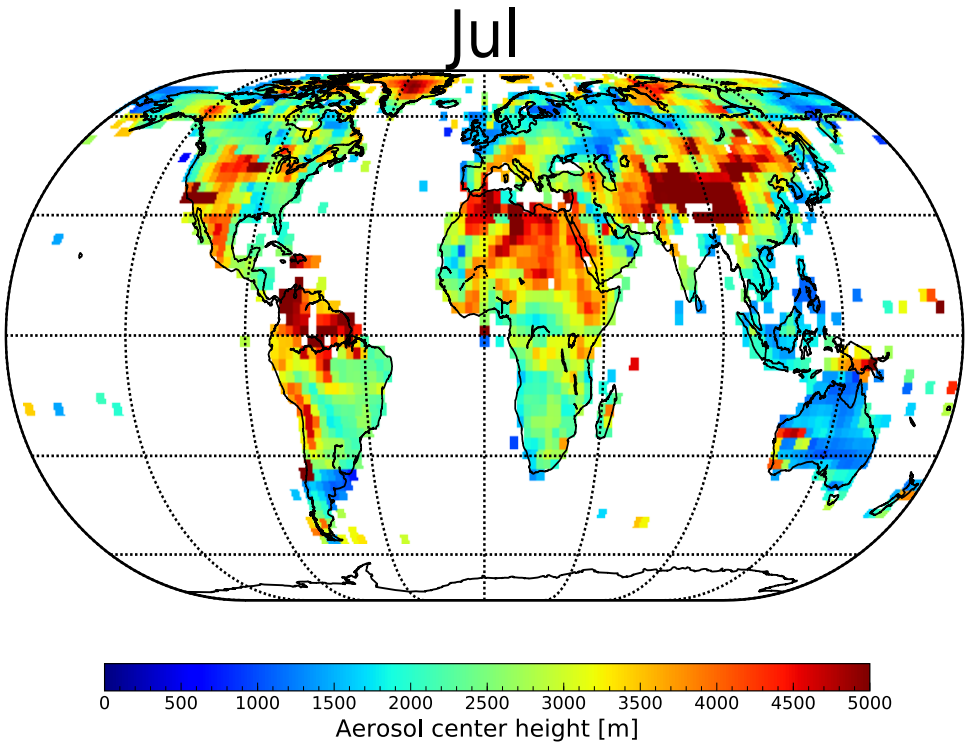
Spectra (HR and MR Spectral Sizing)



Error Analysis

- ISRF error sensitivity
- Additive radiometric offset
- Polarization sensitivity
- Detector non-linearity
- Spectrometer stray light



Comparison of XCO_2 sensitivity to instrument radiometric errors for different spectral instrument sizing (MR versus HR).

Global ensemble of simulated measurements (four seasons) with realistic albedo and aerosol distribution.

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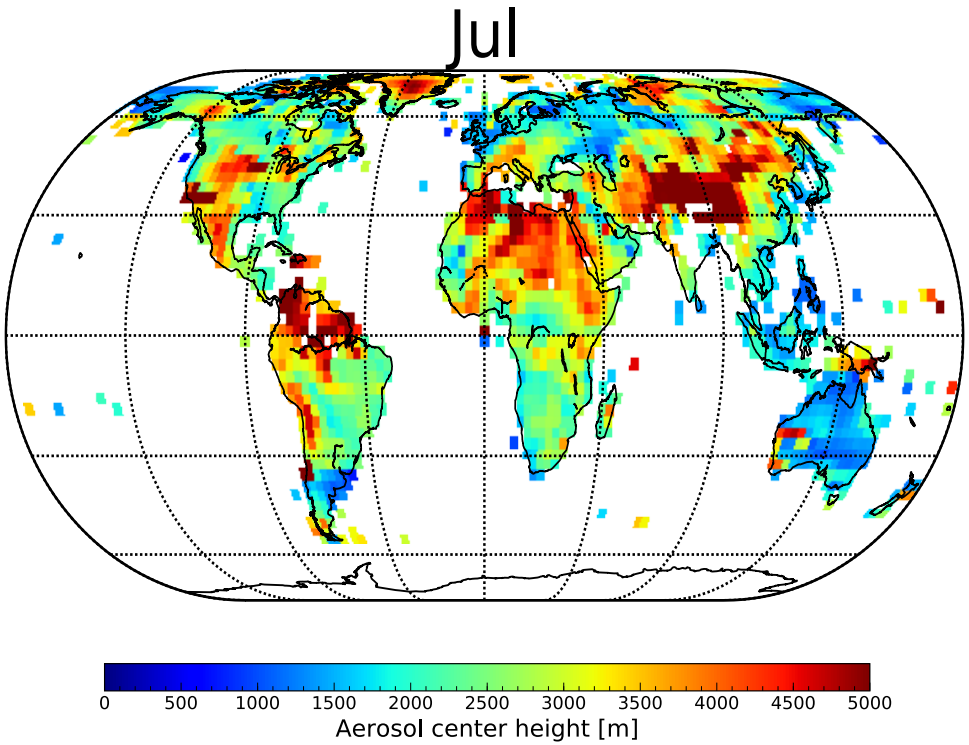
Error analysis

- **ISRF error sensitivity**
- **Additive radiometric offset**
- **Polarization sensitivity**
- **Detector non-linearity**
- **Spectrometer stray light**



Comparison of XCO2 sensitivity to instrument radiometric errors for different spectral instrument sizing (MR versus HR).

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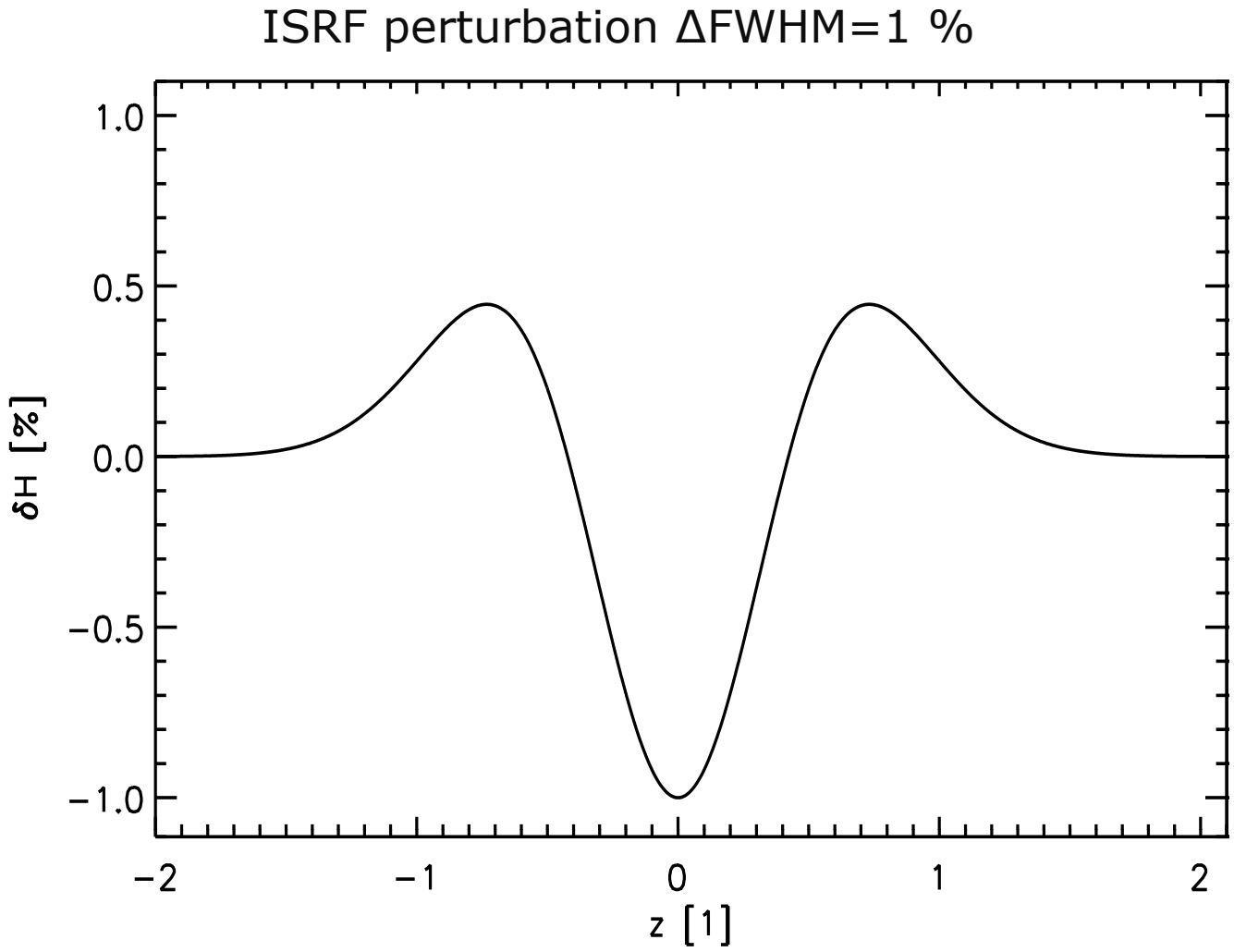
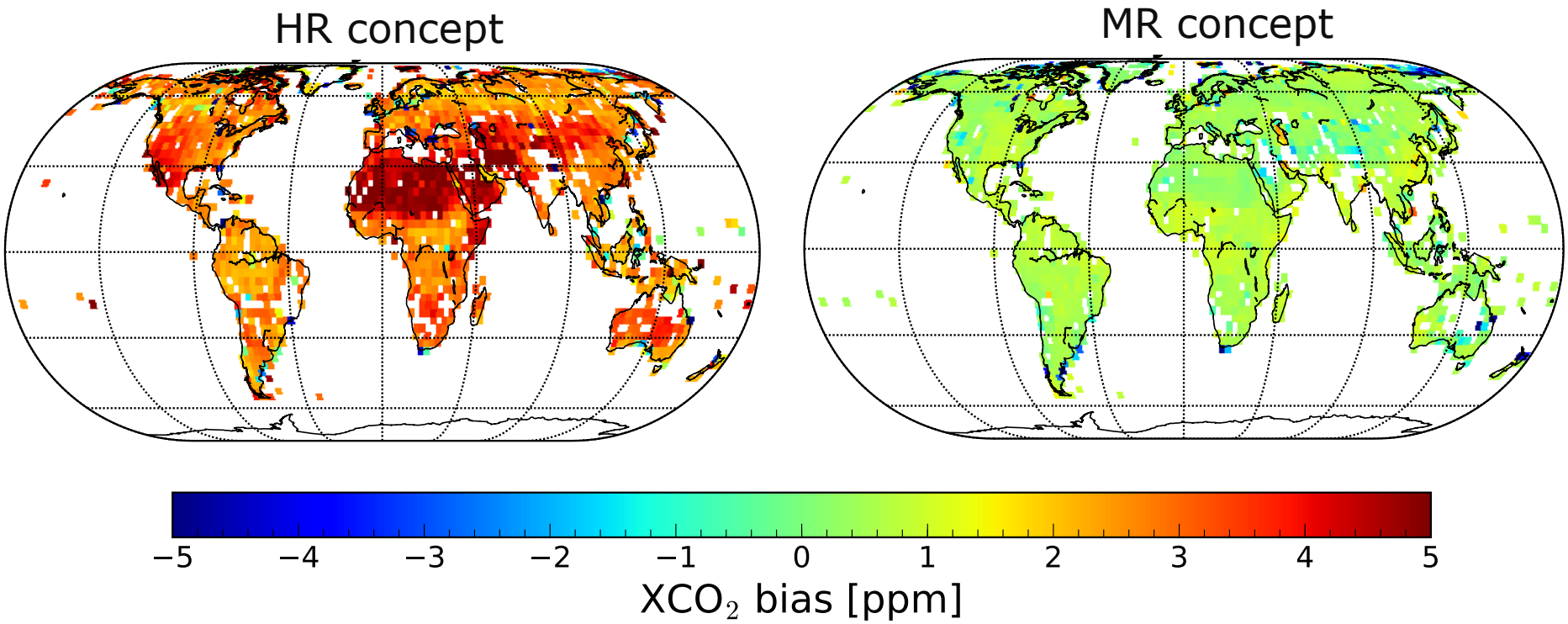
Instrument Spectral Response Function (ISRF)



spectral dimension in units of FWHM

Instrument Spectral Response Function (ISRF)

ISRF perturbation ΔFWHM=1 %



ISRF perturbation induces high frequency spectral errors, with larger interference with the CO_2 sensitivity of the HR then of the MR concept.

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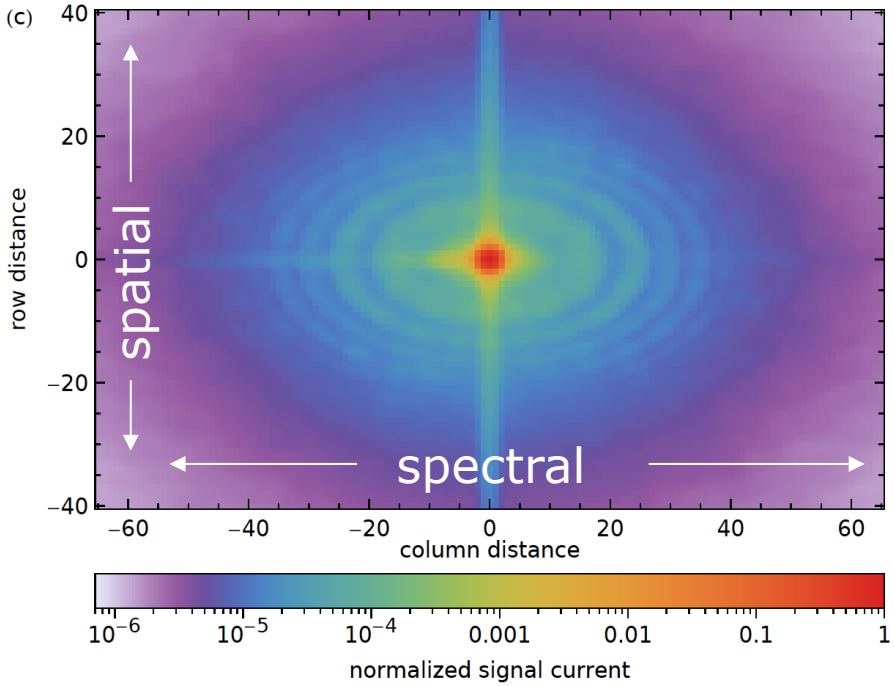
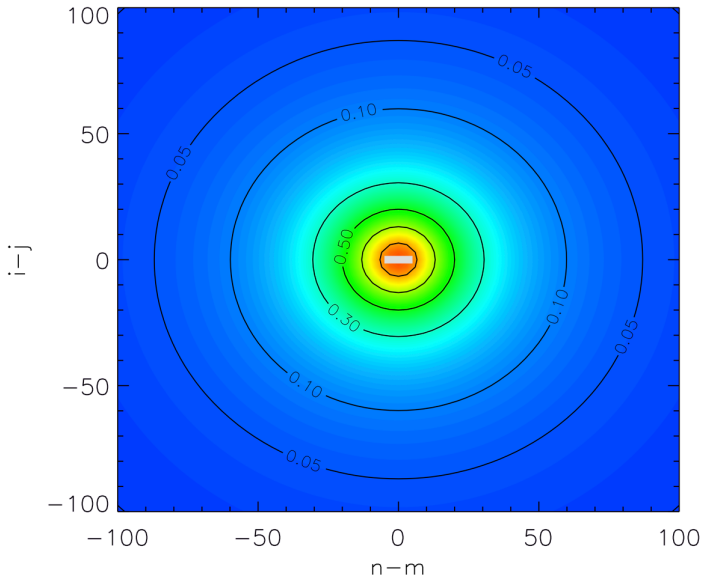
Spectrometer stray light

'Spectrometer stray light' is light in the instrument that is not intended by its design.

TROPOMI



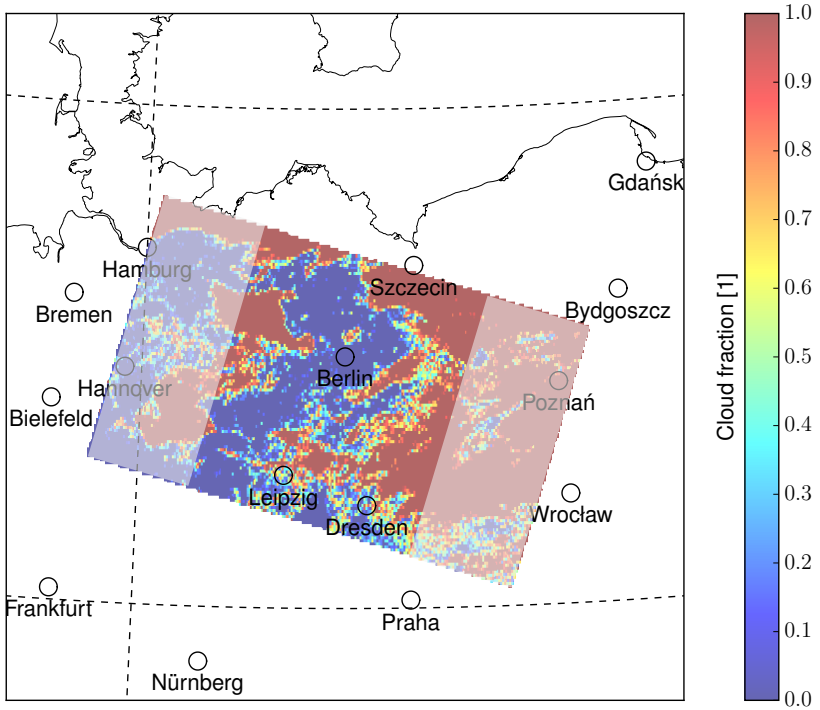
Stray light simulation



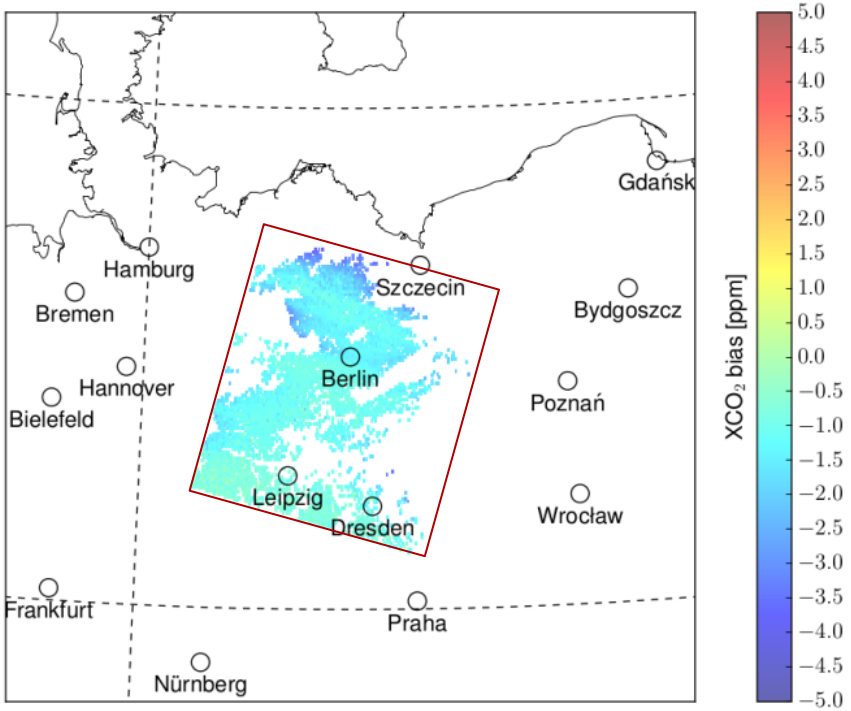
Differences are due to TROPOMI specific stray light contributions by the grating and the telescope.

Stray light induced error: Regional esnsemble

cloud fraction



XCO_2 error



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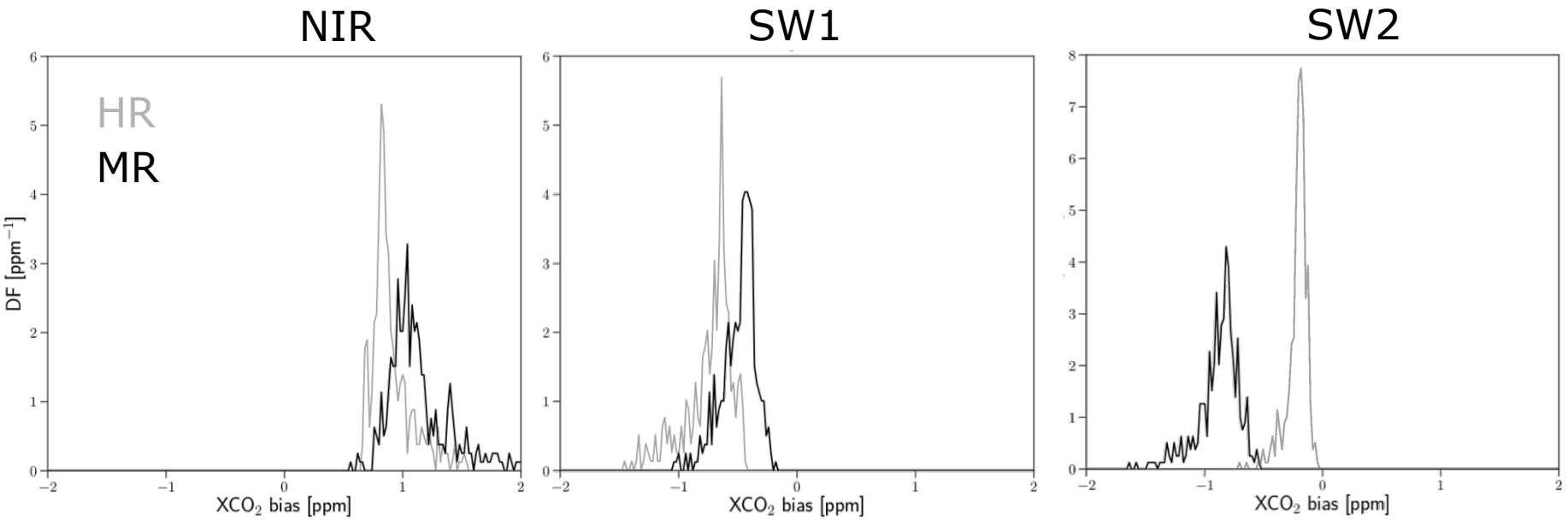
Stray light induced error (per band)



	NIR [ppm]	SW1 [ppm]	SW2 [ppm]
HR	0.91	-0.74	-0.21
MR	1.14	-0.49	-0.88

In the NIR and SW2, the MR spectral sizing shows a slightly higher stray light sensitivity.

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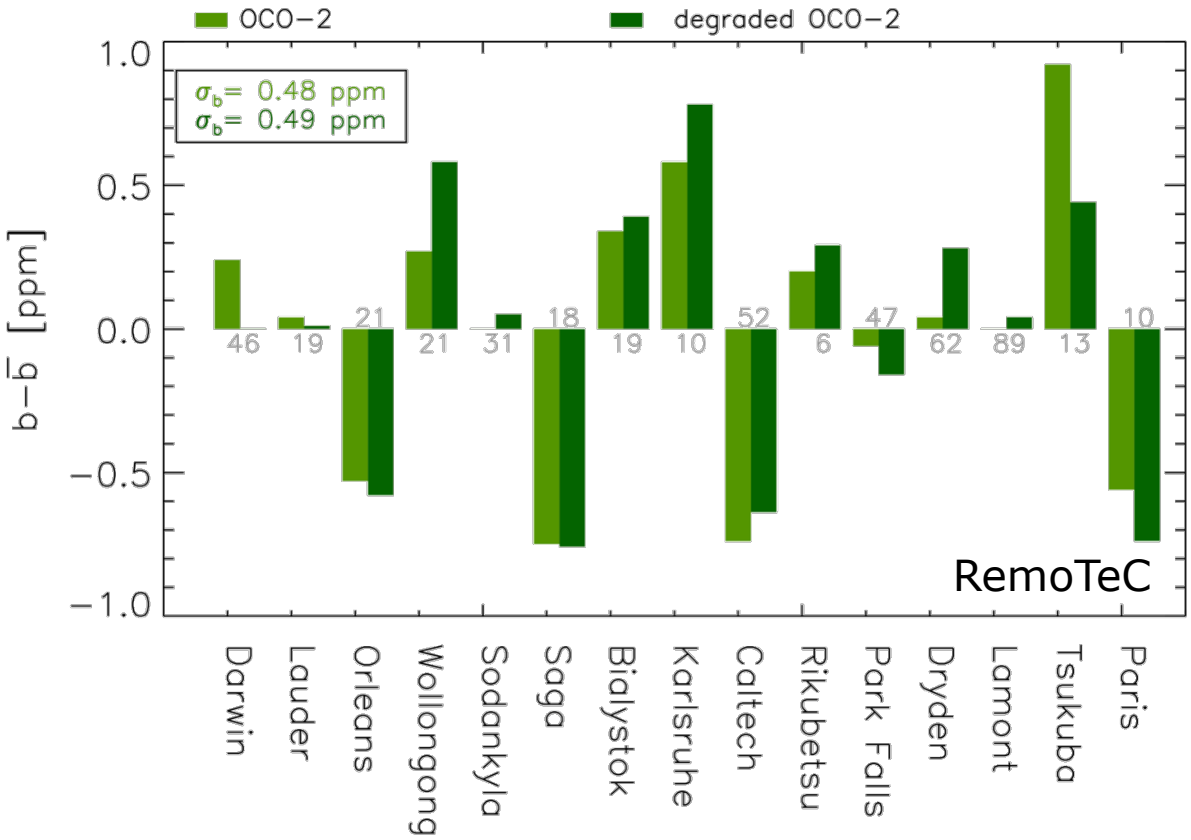
Spectral Degradation of OCO-2 Measurements

- Apply an additional smoothing/sampling to OCO-2 data such that the degraded measurements corresponds to the MR concept
- Adjust measurement error covariance and forward model accordingly.



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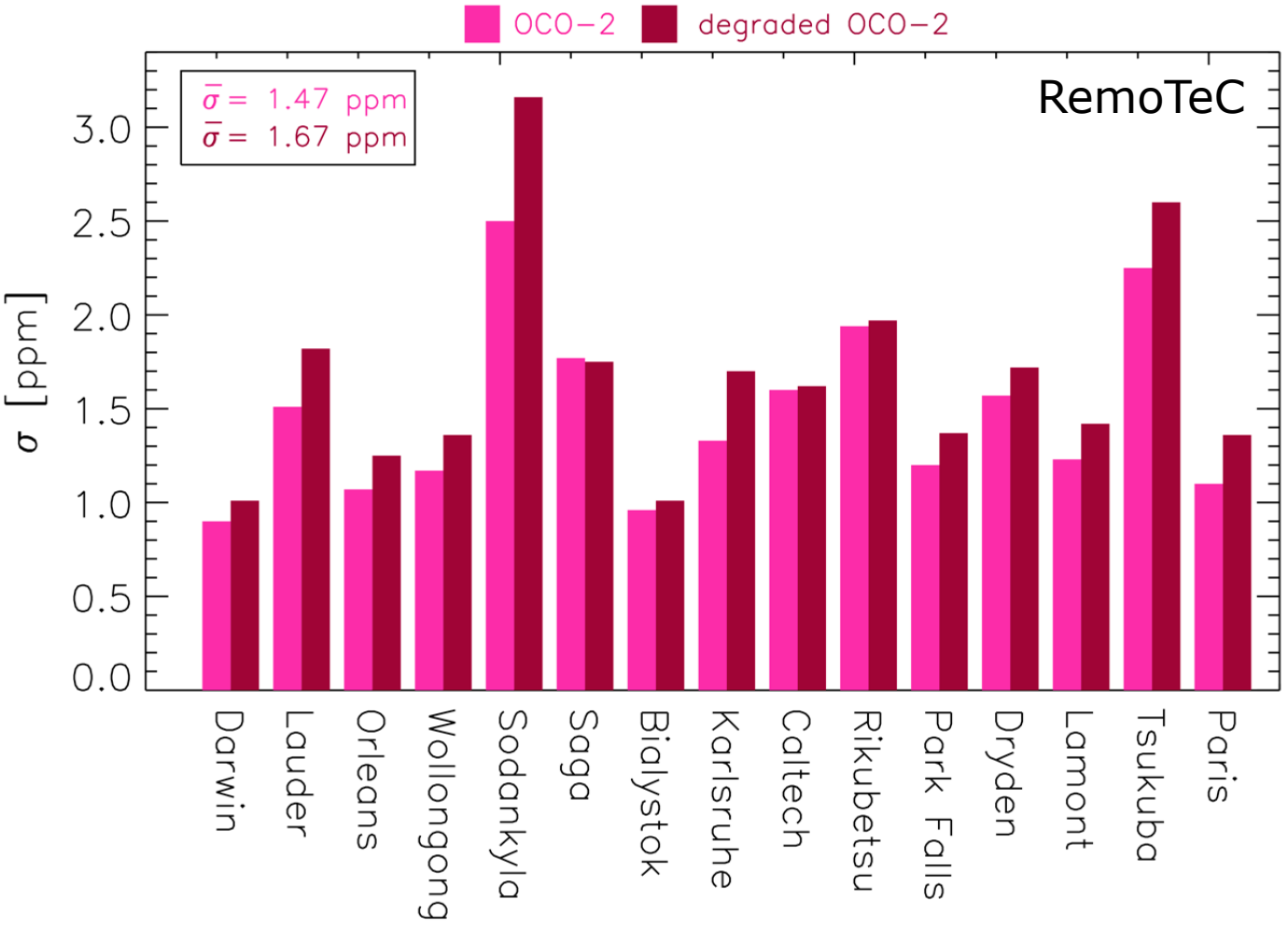
OCO-2 versus TCCON (scatter)



➥**A posteriori spectral degradation of OCO-2 data only affects little data quality**

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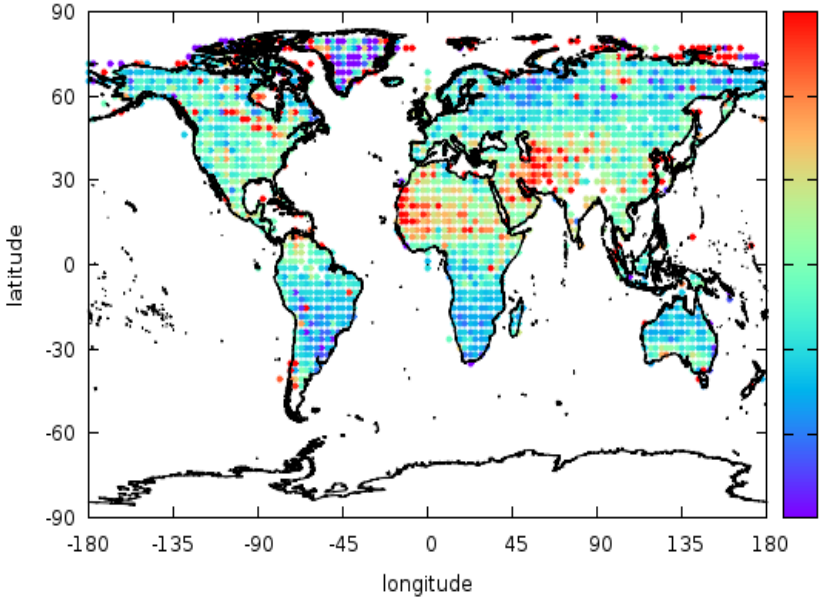
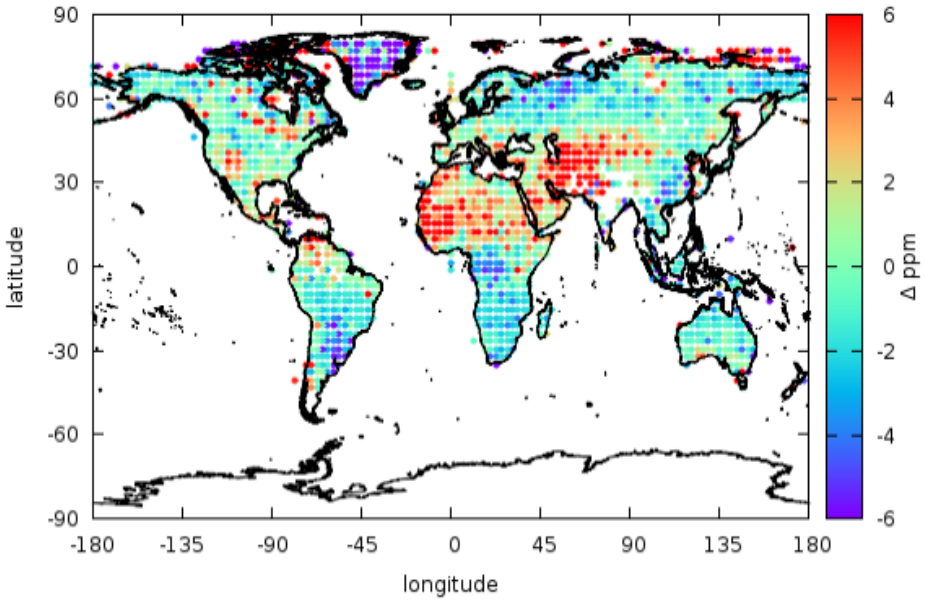
Aerosol induced error

HR



MR



- For the systematic aerosol and cirrus induced XCO2 errors, LR and HR show similar errors < 2 ppm for 50 % (< 4 ppm for 70 %) of the ensemble members
- For all concepts, performance can be improved by employing data filters.

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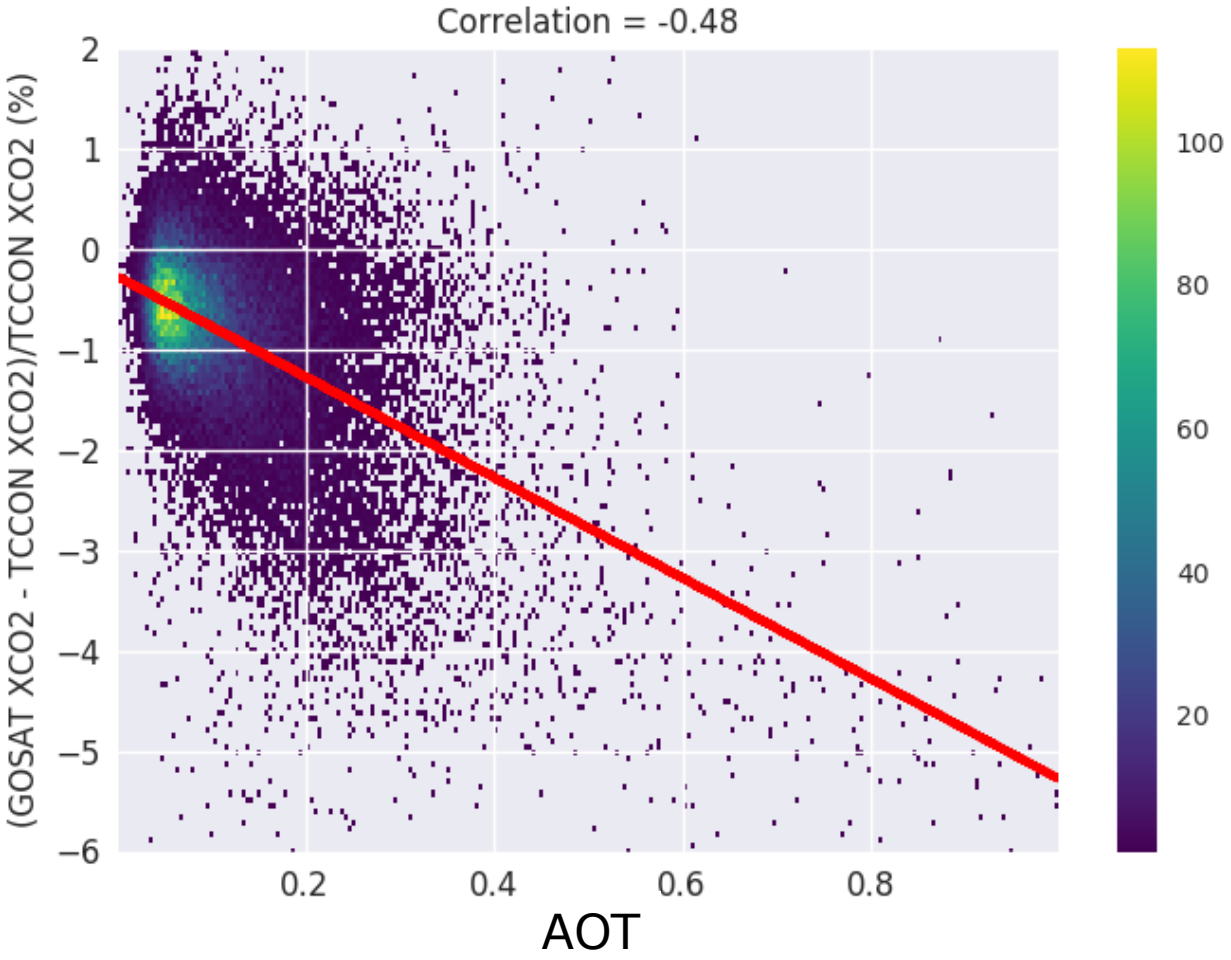
GOSAT – TCCON comparison



GOSAT-TCCON comparison without a posteriori aerosol filtering shows a clear bias dependence on aerosol optical depth.

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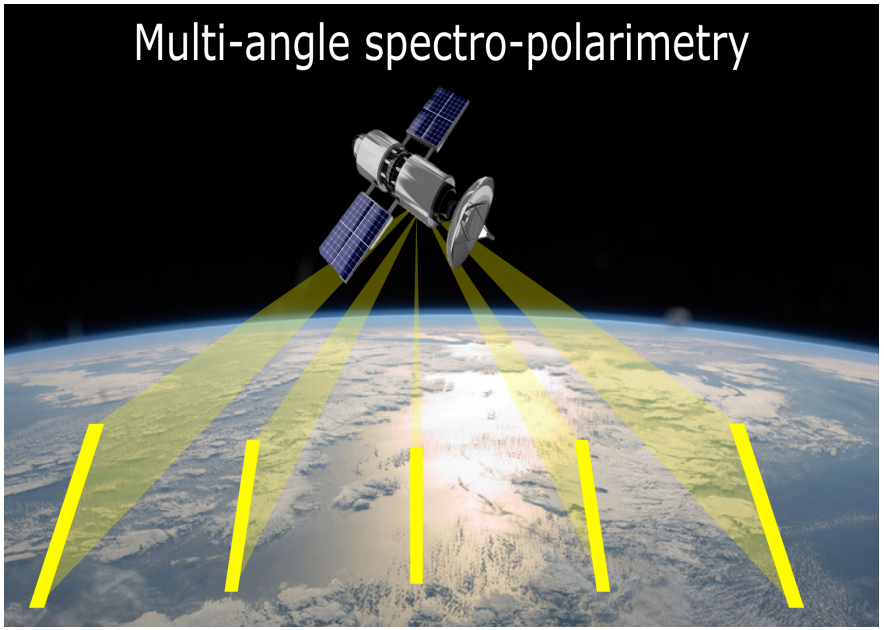
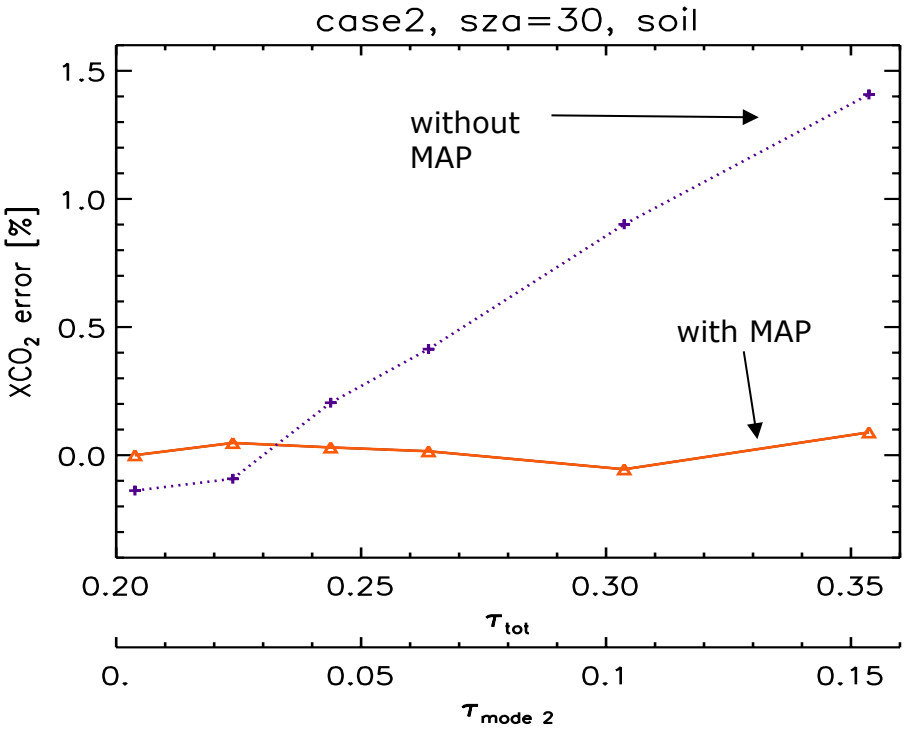
Potential of a Multi-Angle Polarimeter (MAP) for XCO_2 retrievals





- Preliminary results from ESA Sentinel-7 study.
- Synergistic retrieval using MAP and S7 spectrometer.
- Challenging case: Elevated dust layer over urban pollution

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Conclusions

- From the error analysis using simulated measurements, we see no major performance difference for the moderate and high resolution spectral sizing.
- On the whole, this is confirmed by XCO_2 retrievals using OCO-2 data degraded to the moderate spectral resolution.
- It is considered to add a multi-angle polarimeter to support the XCO_2 retrieval with dedicated light path information.