Impact of Raman scattering on XCO_2 and SIF retrievals from OCO-2/3

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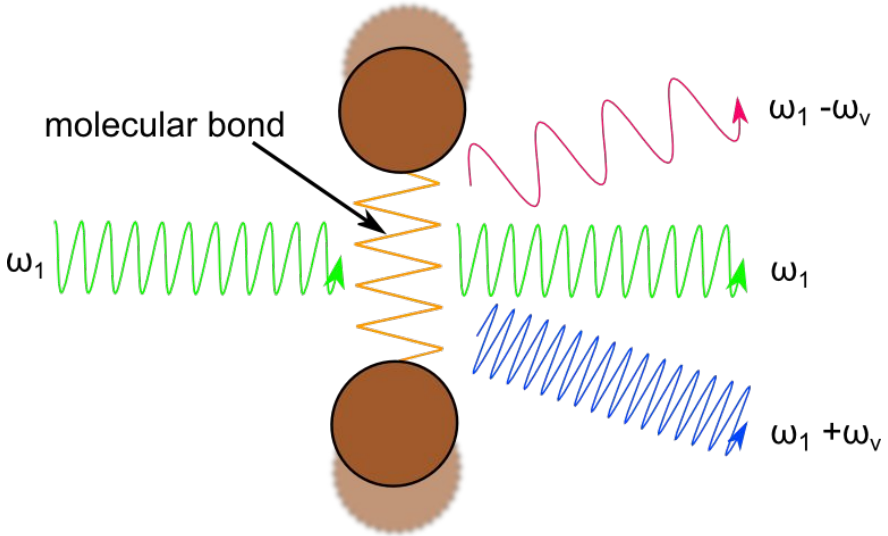
Background

- Ever since its first detection from space, SIF retrievals have required posterior bias corrections using barren reference areas like the Sahara, Antarctica, and Greenland – these biases were assumed attributable to instrument artefacts encapsulated as the “zero level offset” (ZLO)
- Recent advances in radiative transfer modeling have revealed that these biases may be explained by rotational Raman scattering (RRS)
- The resulting simulations could explain part of the original biases in SIF, as well as residual biases that remained after ZLO corrections
- We have generated a lookup table (LuT) to correct for RRS biases in SIF and XCO_2 retrievals from OCO-⅔ and other instruments

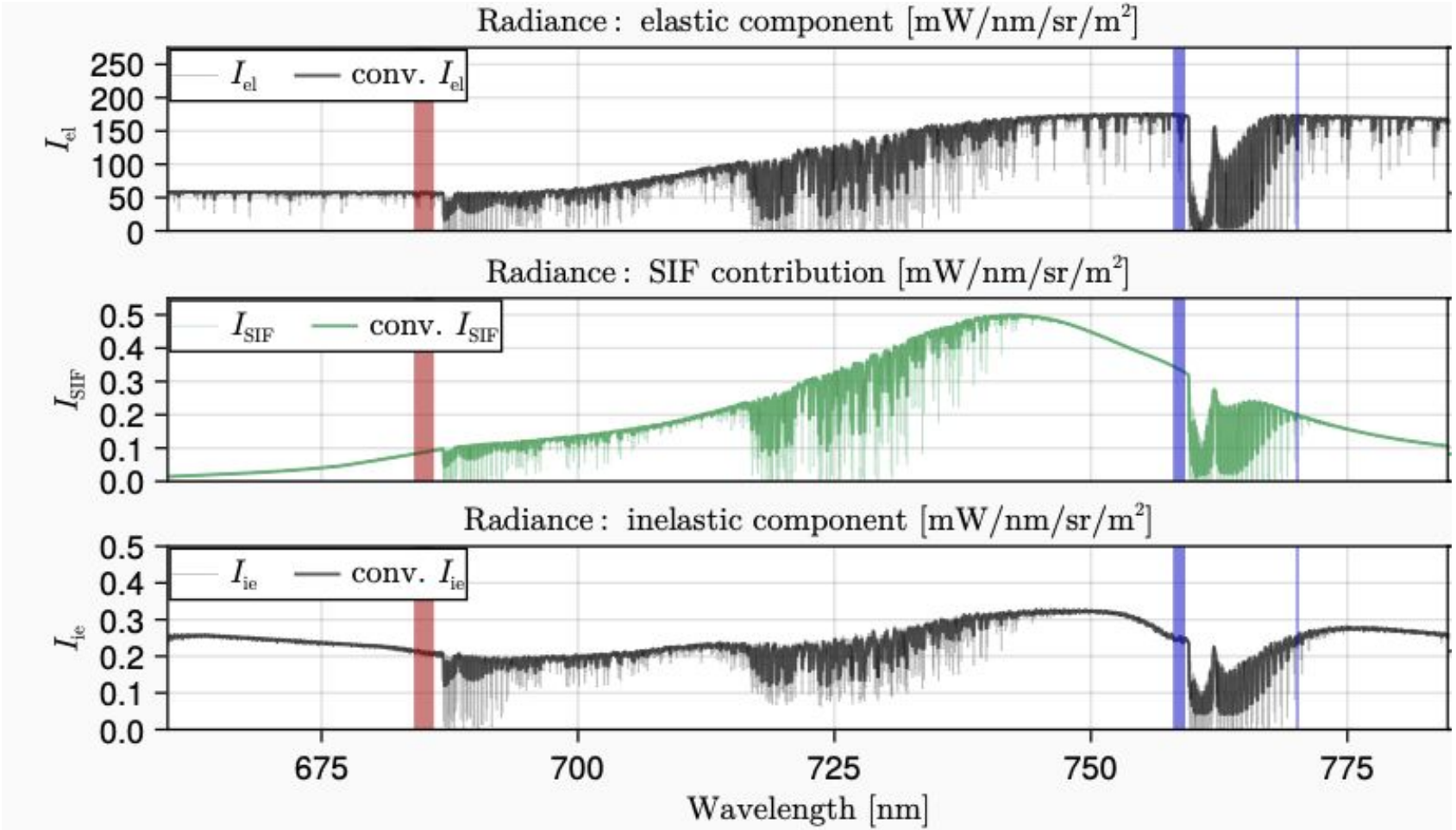
Raman Scattering Basics

Sanghavi, Raman scattering in the earth's atmosphere, part I: Optical properties, JQSRT 2022

Sanghavi and Frankenberg, Raman scattering in the Earth's atmosphere, Part II: Radiative transfer modeling for remote sensing applications, JQSRT 2023

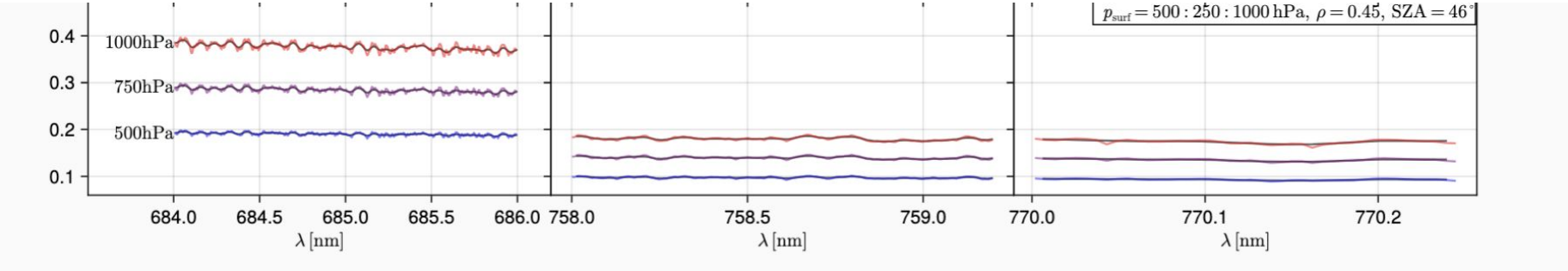


How does RRS affect SIF retrievals?

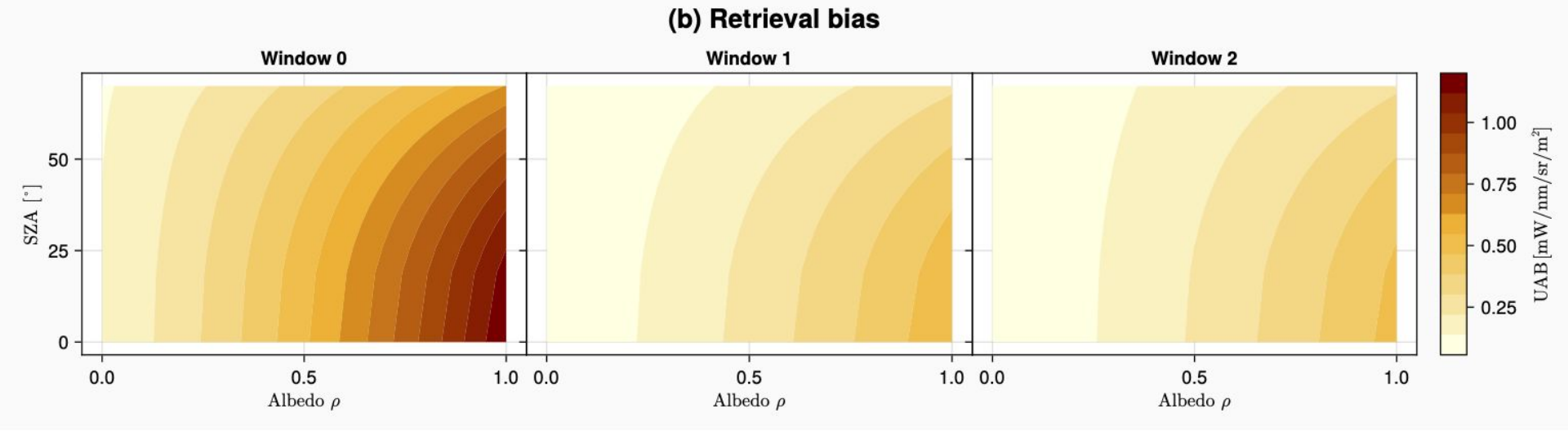


How does RRS affect SIF retrievals?

Surface Pressure (mostly topography)

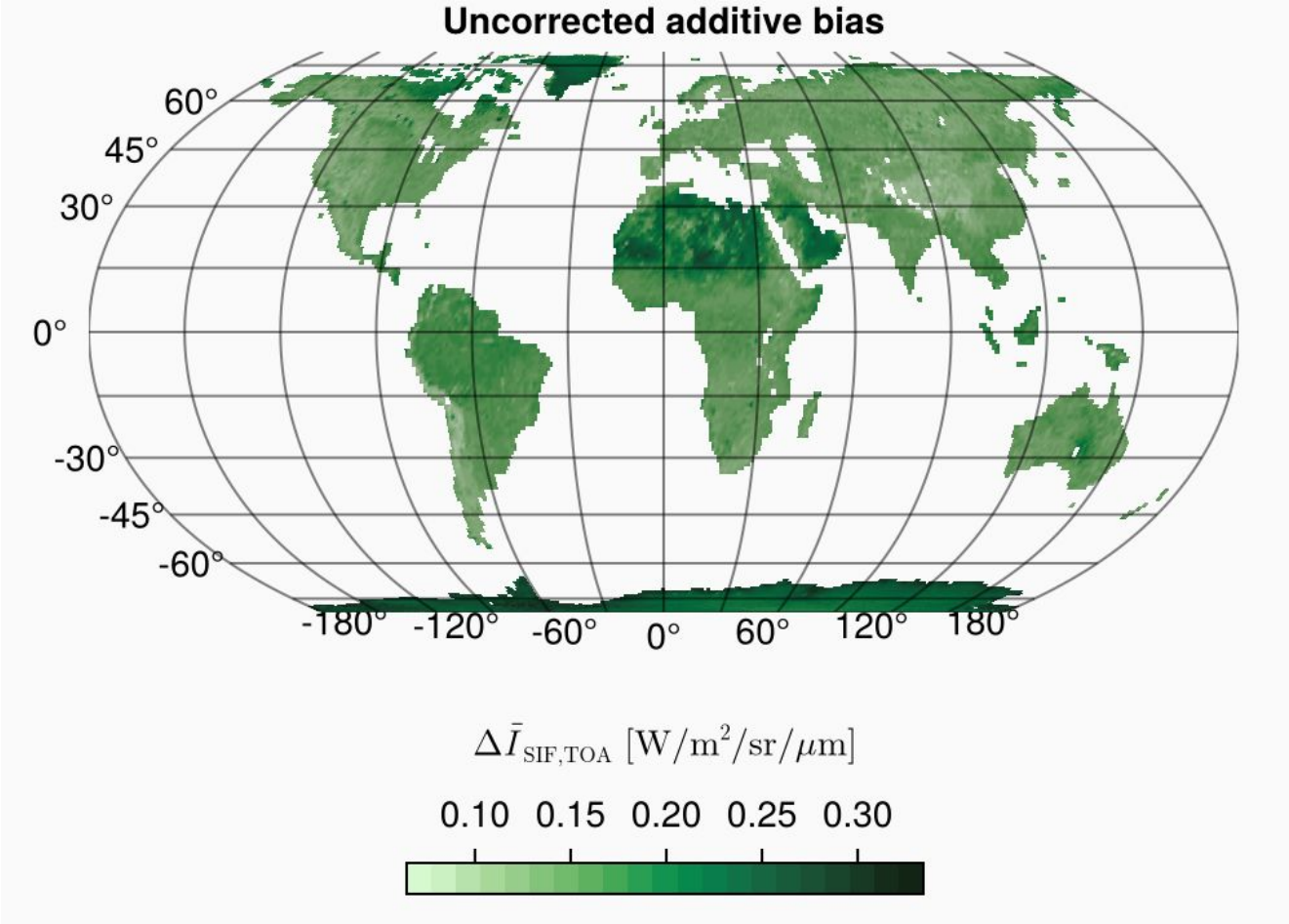


How does RRS affect SIF retrievals?

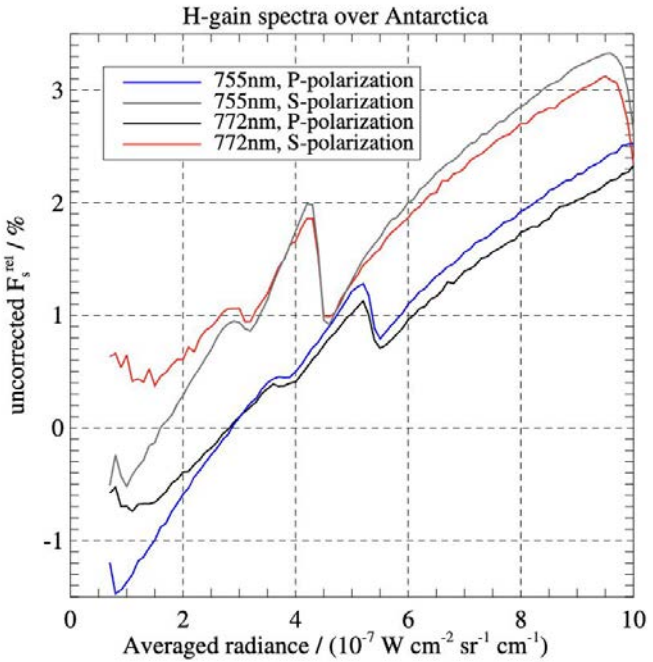


685 nm 755 nm 771 nm

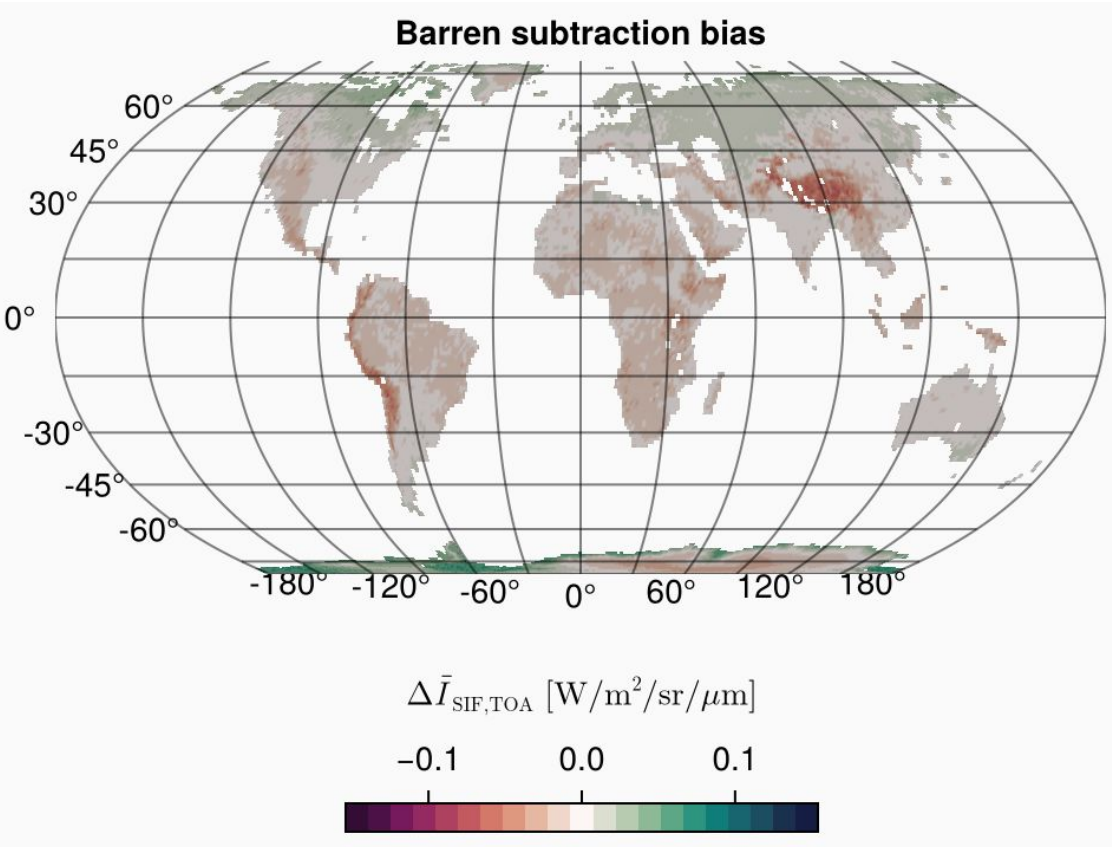
Uncorrected SIF: Simulated biases



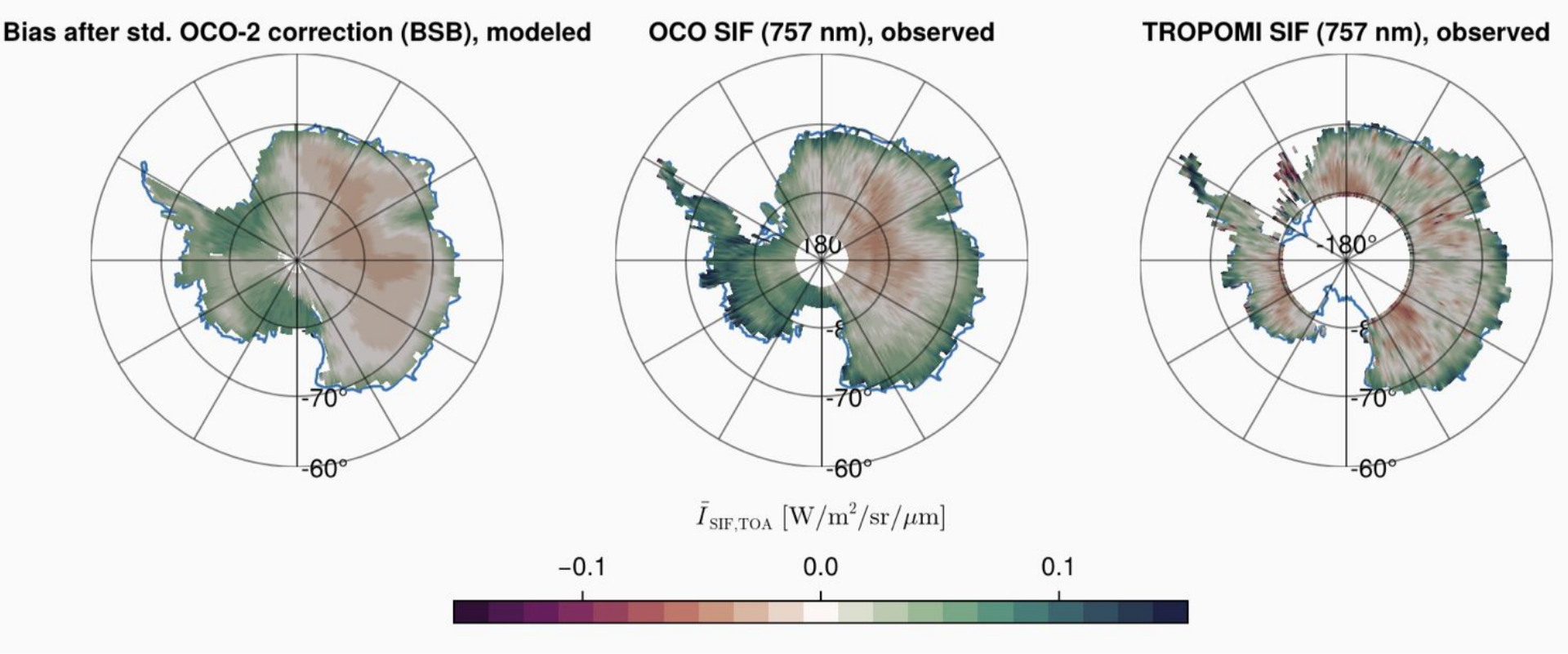
ZLO corrected SIF: GOSAT observations, simulated biases



Frankenberg et al. 2013

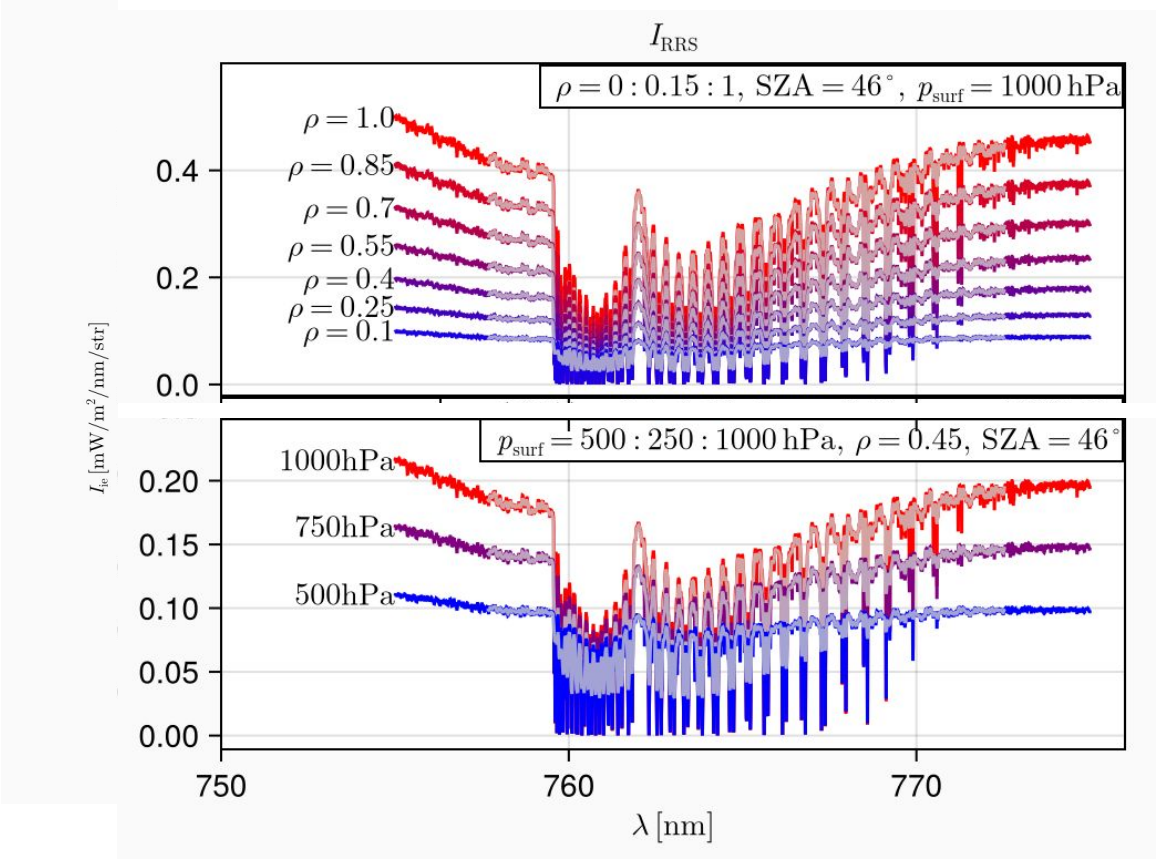


ZLO corrected SIF: simulated biases, OCO-2/TROPOMI observations



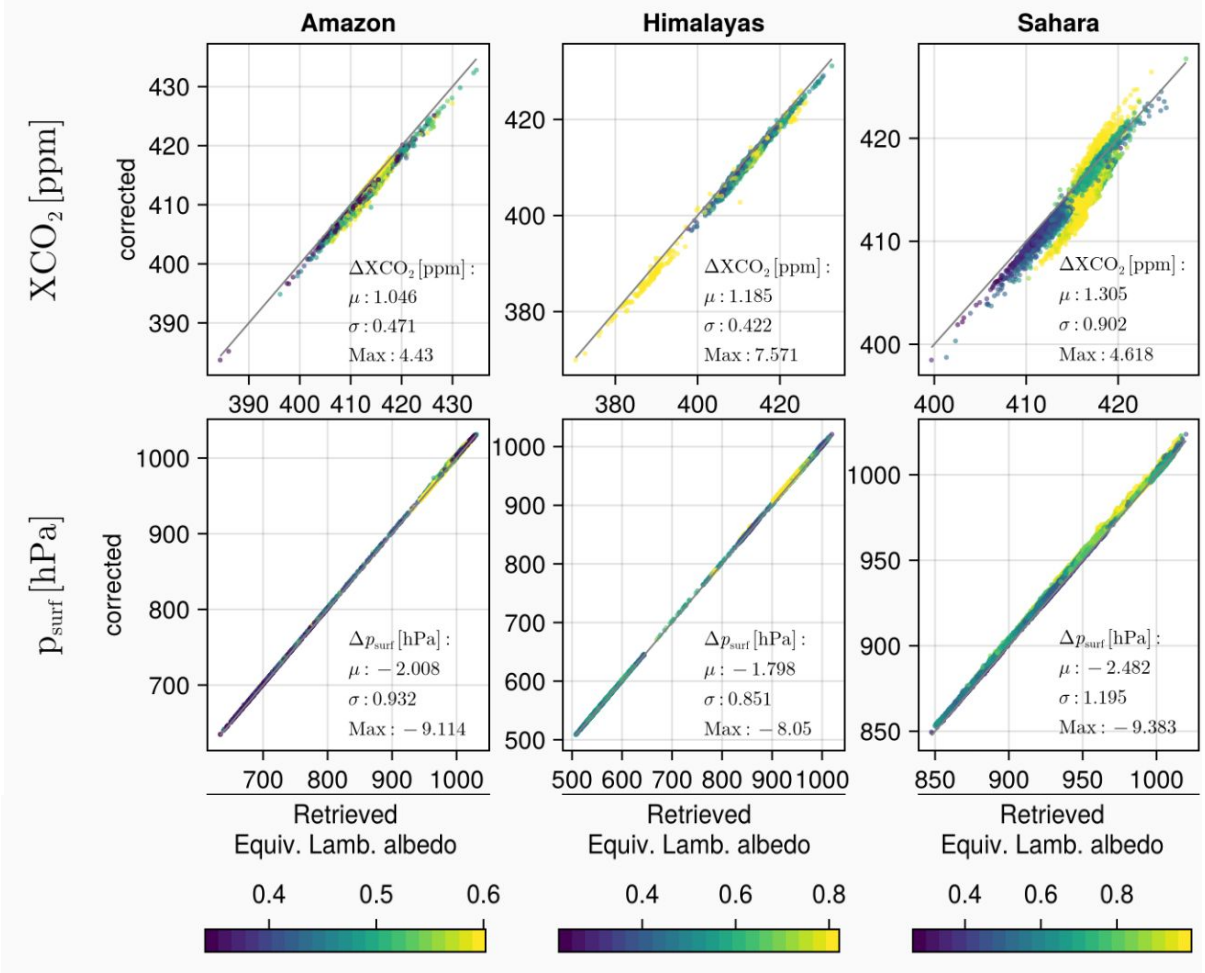
Sanghavi et al. (in press)

Effect of RRS on XCO_2 using the O_2 A-band: first results



Sanghavi et al. (in prep.)

Effect of RRS on XCO_2 using the O2 A-band: first results (with vs without RRS correction)



NOT negligible if we require <0.5-1ppm biases

Sanghavi et al. (in prep.)

Summary and outlook

- RRS causes infilling in Fraunhofer lines and the O_2 A-band causing biases in SIF (simple and linear) and p_{surf}/XCO_2 retrievals (complex and non-linear).

- RRS biases depend on surface brightness, pressure, and viewing geometry, reaching ±0.15 mW/nm/sr/m^2 (for ZLO-corrected SIF) and a few ppm for XCO_2

- RRS corrections to be incorporated in build 12 (B12) of the OCO-⅔ operational products (now pending NASA budgetary decisions)