Supplement of

Synthetic mapping of XCO_2 retrieval performance from shortwave infrared measurements: impact of spectral resolution, signal-to-noise ratio and spectral band selection

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1 Overview

This supplement provides the exact list of resolving power values (Table S1) and average albedo values for the three surface models considered in this work (Table S2). It gives results for all observational situations (Figures S2 – S7 and S9 – S14), different a posteriori correlation matrices (Figures S15 – S18), and a version of Fig. 5 in linear scale for the horizontal axis (S9).

2 Contents of this file

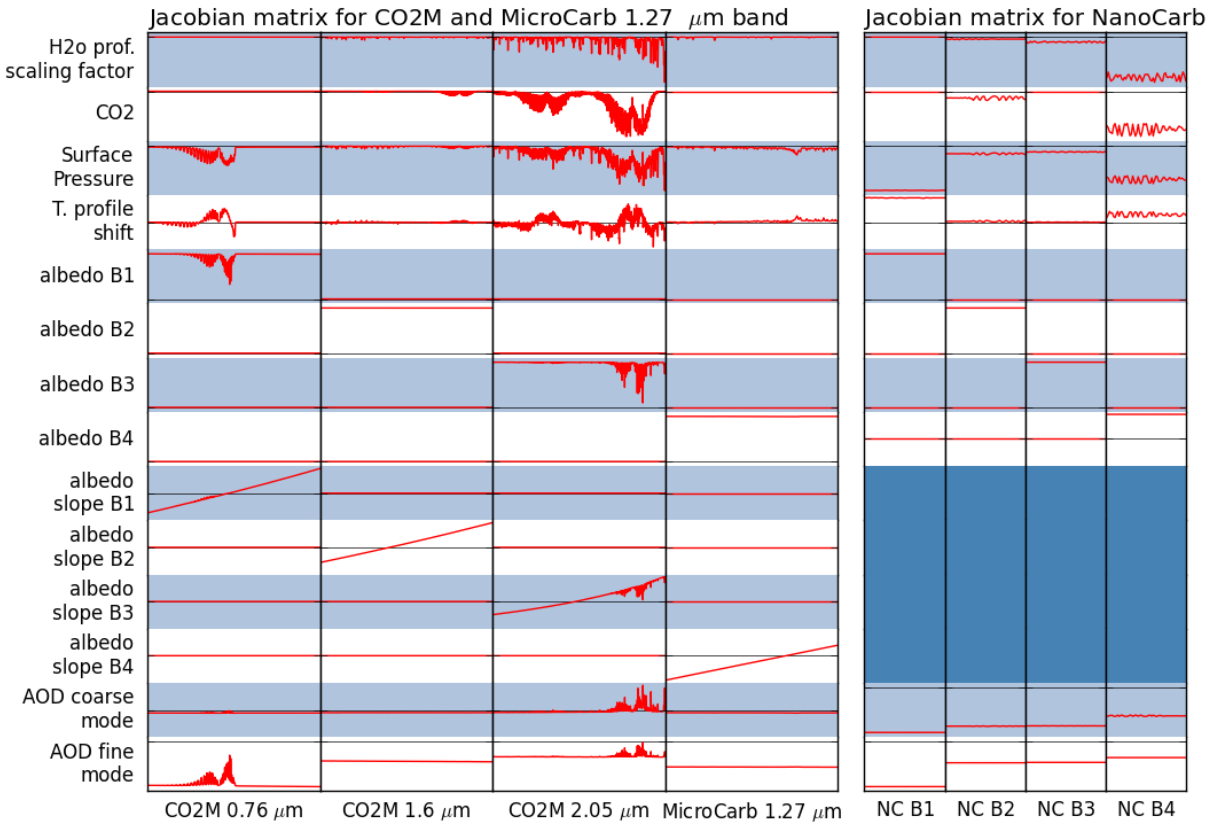
Table S1 and Figures S1 to S18.

200	289	378	467	556	644	733	822	911
1000	2000	3000	4000	5000	6000	7000	8000	9000
10000	12222	14444	16667	18889	21111	23333	25556	27778
30000								

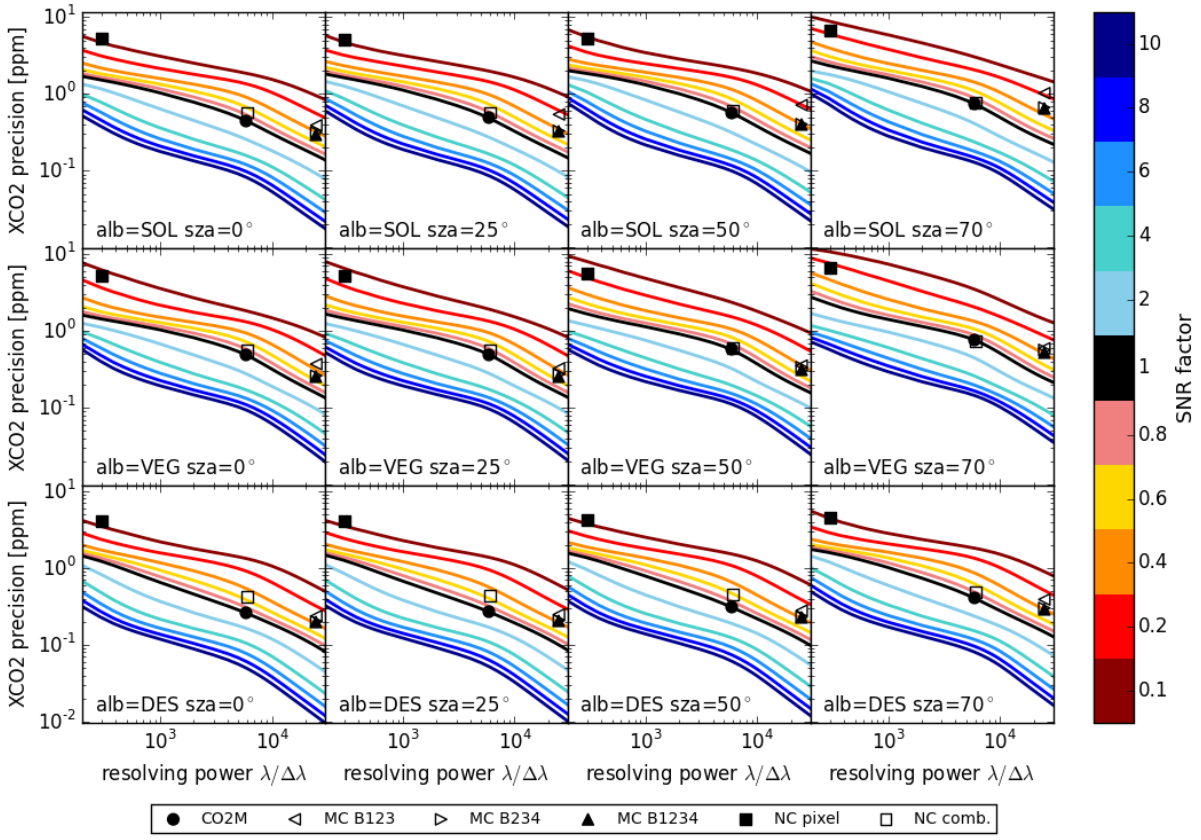
Table S1. Exact list of resolving power values used in this work.

	SOL	VEG	DES
O_2 0.76 µm band	0.10	0.45	0.50
CO_2 1.6 µm band	0.22	0.29	0.57
CO_2 2.05 µm band	0.18	0.09	0.58
O_2 1.27 µm band	0.21	0.47	0.57

Table S2. Albedo values for the three surface models used in this work, averaged over MicroCarb bands.



25 Figure S1. Relative measurement sensitivities at $\lambda/\Delta\lambda$ = 15000 for all state vector variables, for all CO_2M spectral bands and for MicroCarb 1.27 μm O_2-sensitive band (left), and relative NanoCarb measurement sensitivities for all NanoCarb bands (right), for a vegetation-like albedo and a Solar Zenith Angle of 50º. Black horizontal line show the zero level and the vertical scale are arbitrary.



30 Figure S2. X_{CO_2} precision, or random error, for the fictitious CVAR instrument for resolving power $\lambda/\Delta\lambda$ evolving from 200 to 30000 (horizontal axis), and for SNR evolving from 0.1 to 10 times CO_2M reference SNR (colour scale), for SOL, VEG and DES albedo models (rows), and SZA values ranging from 0º to 70º (columns). Symbols give the same quantities for NanoCarb (NC, squares), MicroCarb (MC, triangles) and CO_2M (circle).

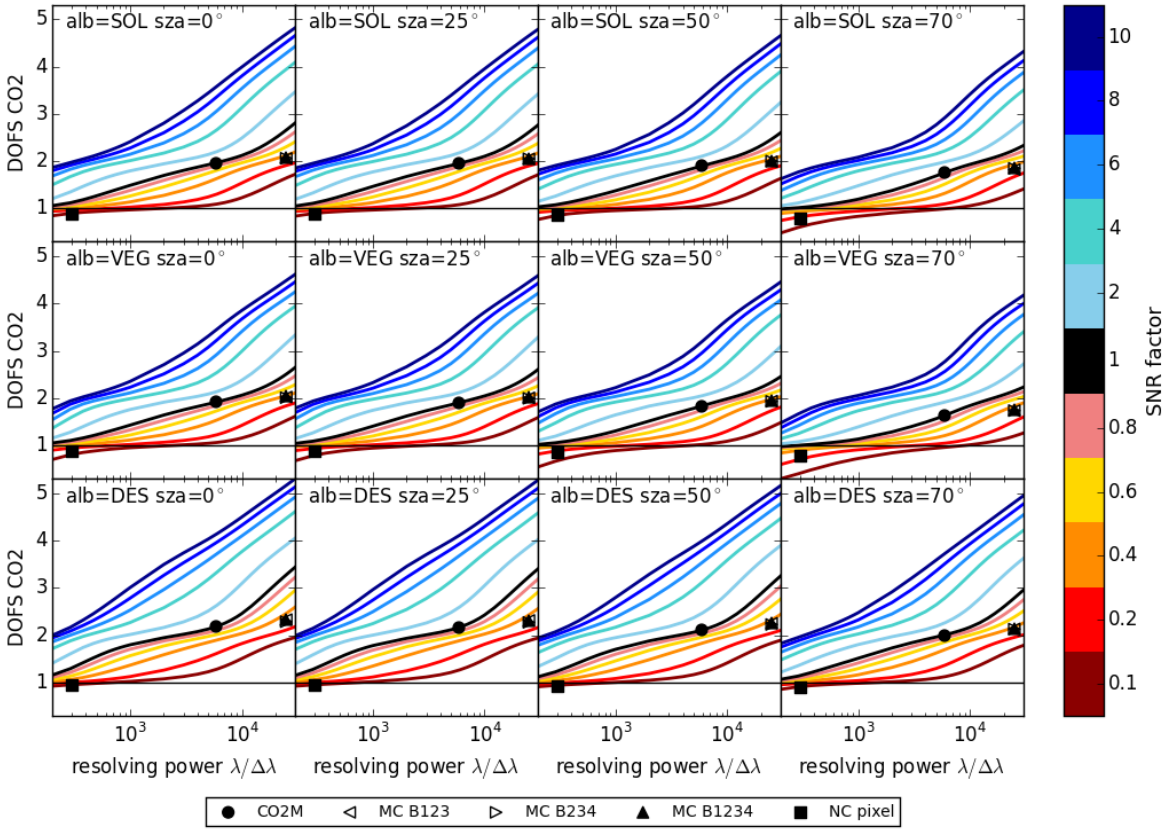


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Figure S3. CO_2 degrees of freedom for the fictitious CVAR instrument for resolving power $\lambda/\Delta\lambda$ evolving from 200 to 30000 (horizontal axis), and for SNR evolving from 0.1 to 10 times CO_2M reference SNR (colour scale), for SOL, VEG and DES albedo models (rows), and SZA values ranging from 0º to 70º (columns). Symbols give the same quantities for NanoCarb (NC, squares), MicroCarb (MC, triangles) and CO_2M (circle).

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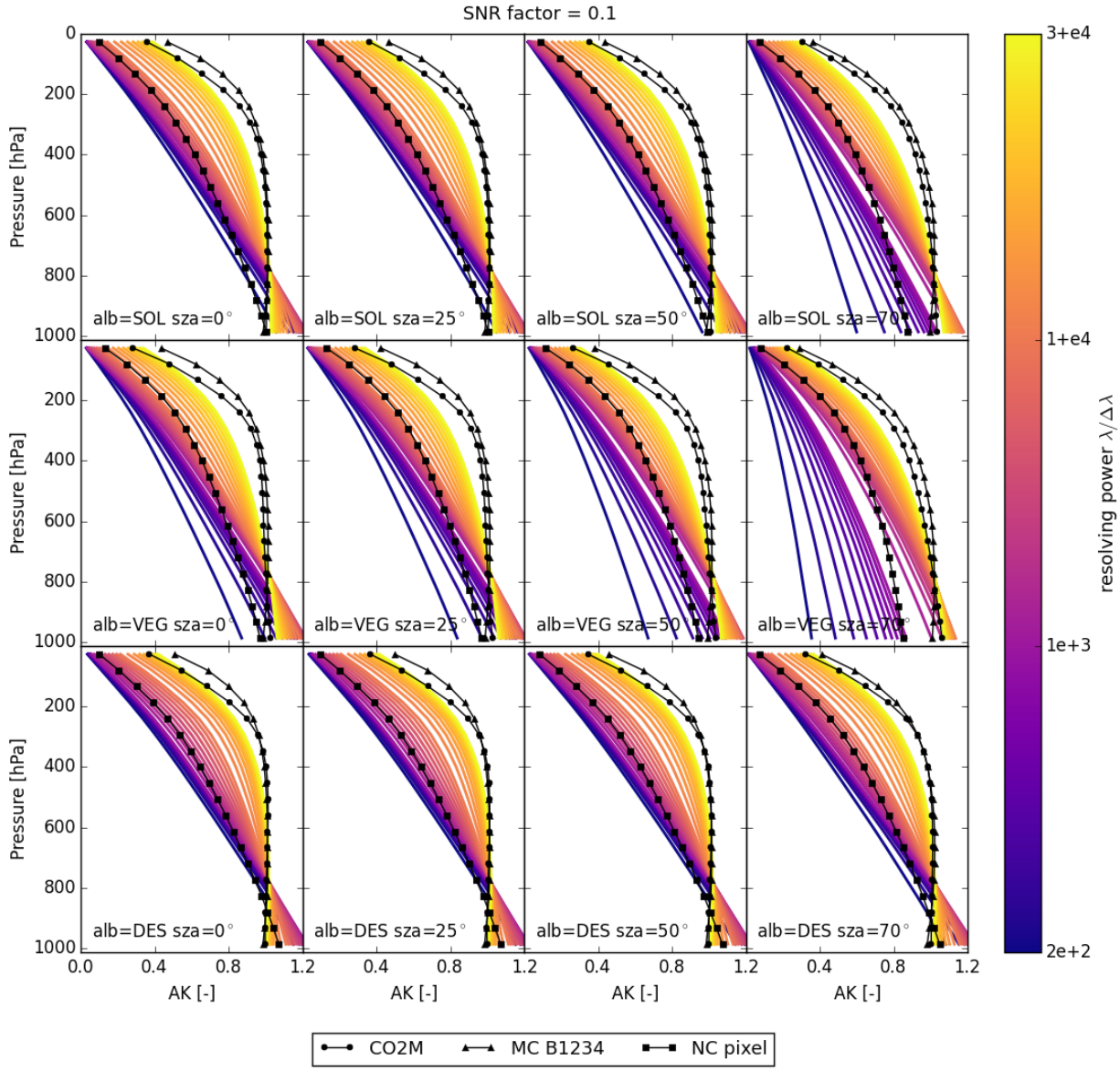

Figure S4. Vertical sensitivities (AKs) as a function of resolving power $\lambda/\Delta\lambda$ for an SNR scaling factor of 0.1, for SOL, VEG and DES albedo models (rows), and SZA values ranging from 0º to 70º (columns). Black lines with symbols give vertical sensitivities for CO_2M (circles), MicroCarb (triangles) and NanoCarb (squares).

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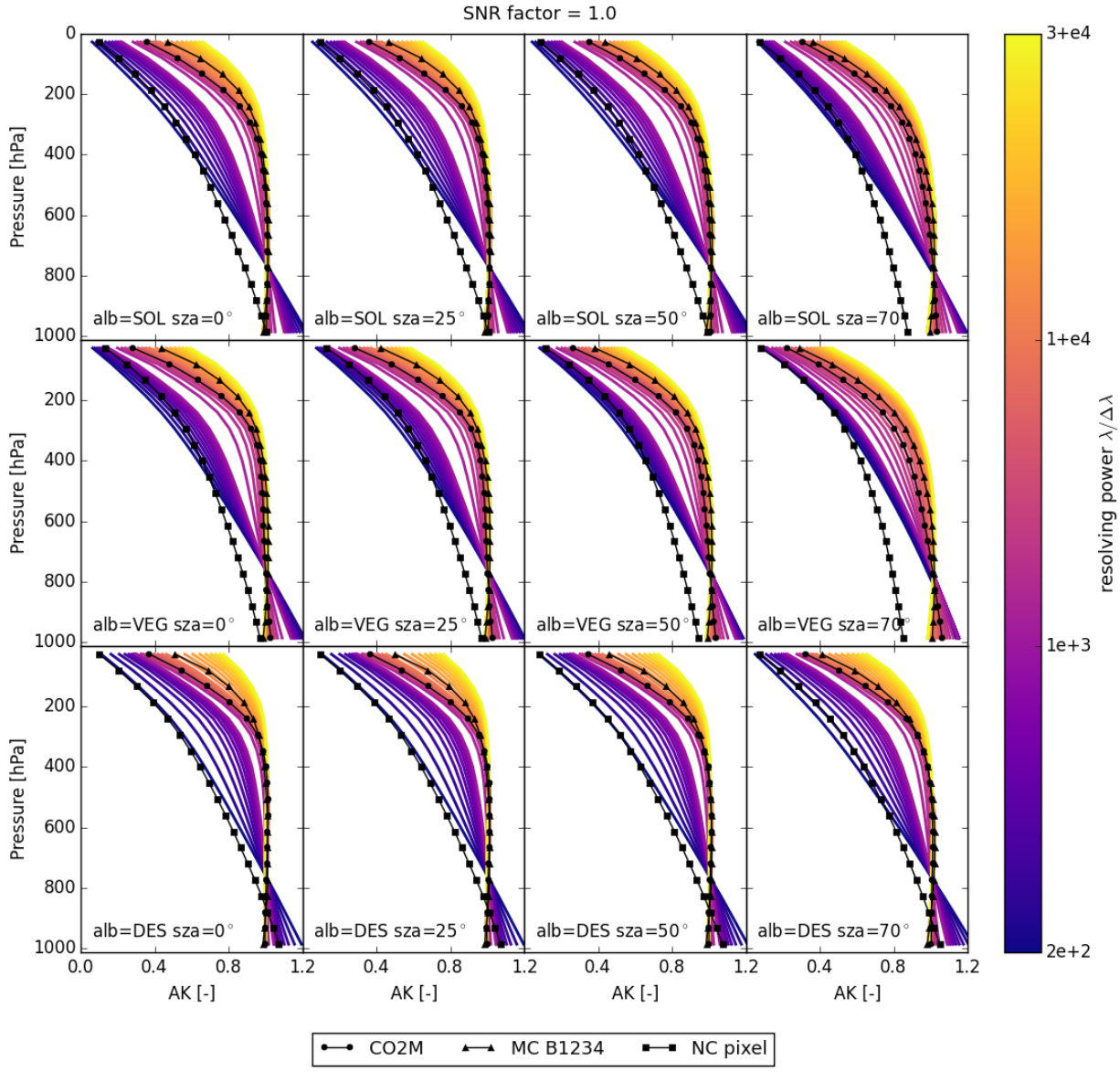

Figure S5. Vertical sensitivities (AKs) as a function of resolving power $\lambda/\Delta\lambda$ for an SNR scaling factor of 1, for SOL, VEG and DES albedo models (rows), and SZA values ranging from 0º to 70º (columns). Black lines with symbols give vertical sensitivities for CO_2M (circles), MicroCarb (triangles) and NanoCarb (squares).

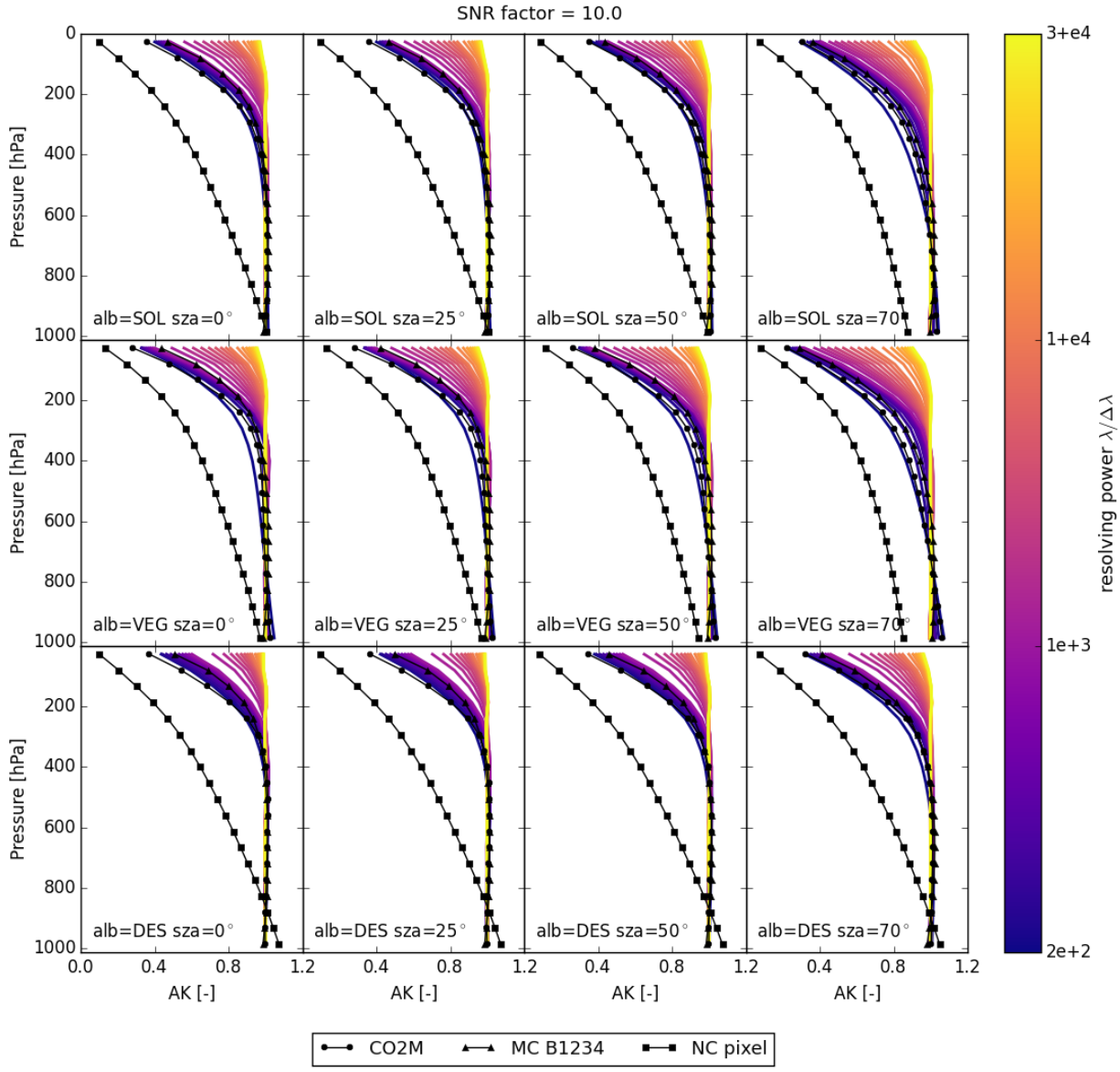

Figure S6. Vertical sensitivities (AKs) as a function of resolving power $\lambda/\Delta\lambda$ for an SNR scaling factor of 10, for SOL, VEG and DES albedo models (rows), and SZA values ranging from 0º to 70º (columns). Black lines with symbols give vertical sensitivities for CO_2M (circles), MicroCarb (triangles) and NanoCarb (squares).

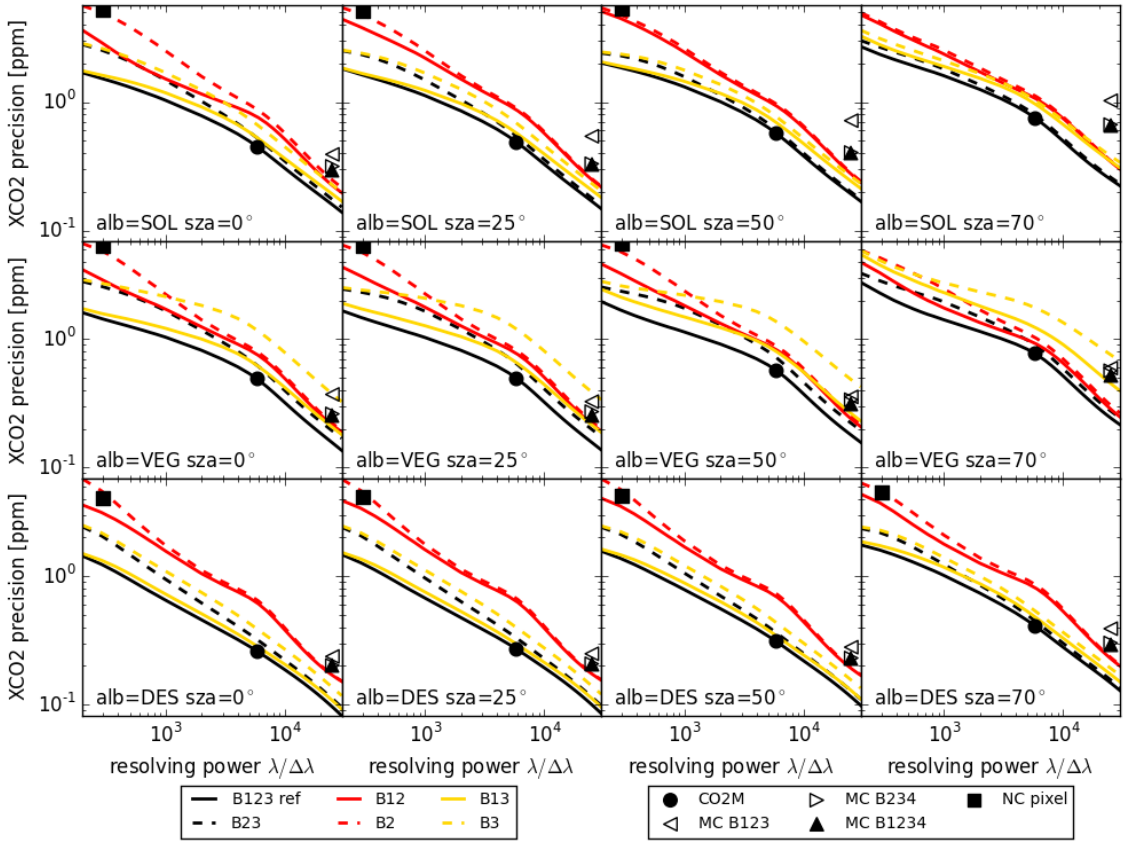

Figure S7. X_{CO_2} precision, or random error, for the fictitious CVAR instrument for resolving power $\lambda/\Delta\lambda$ evolving from 200 to 30000 (horizontal axis), and for different spectral band selections: with and without O_2 0.76 µm band (B1, full and dashed-lines, respectively), with both CO_2 1.6 and 2.05 µm bands (B23, black), with only the 1.6 µm band (B2, red) and with only the 2.05 µm band (B3, yellow), for SOL, VEG and DES albedo models (rows), and SZA values ranging from 0º to 70º (columns). Symbols give the same quantities for NanoCarb (NC, squares), MicroCarb (MC, triangles) and CO_2M (circle).

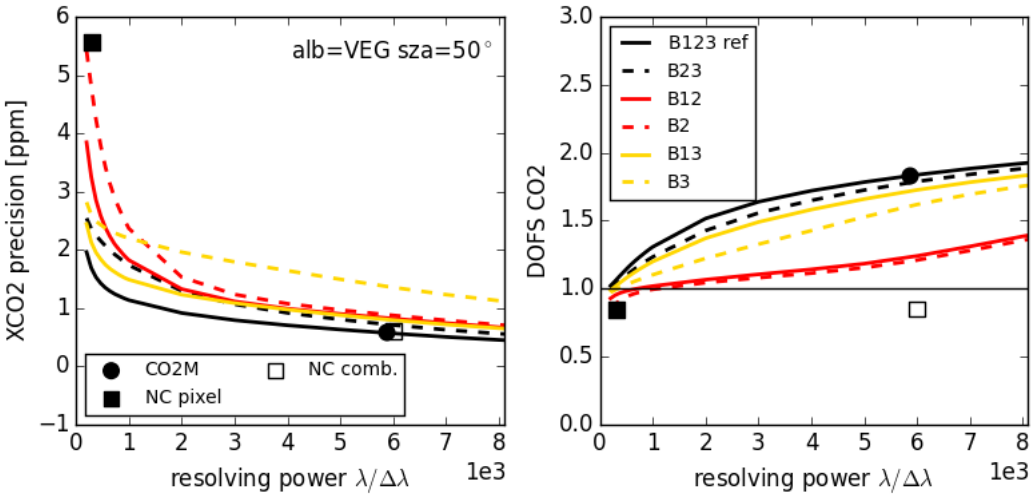

Figure S8. Same as Fig. 5, but in linear scale for the horizontal axis.

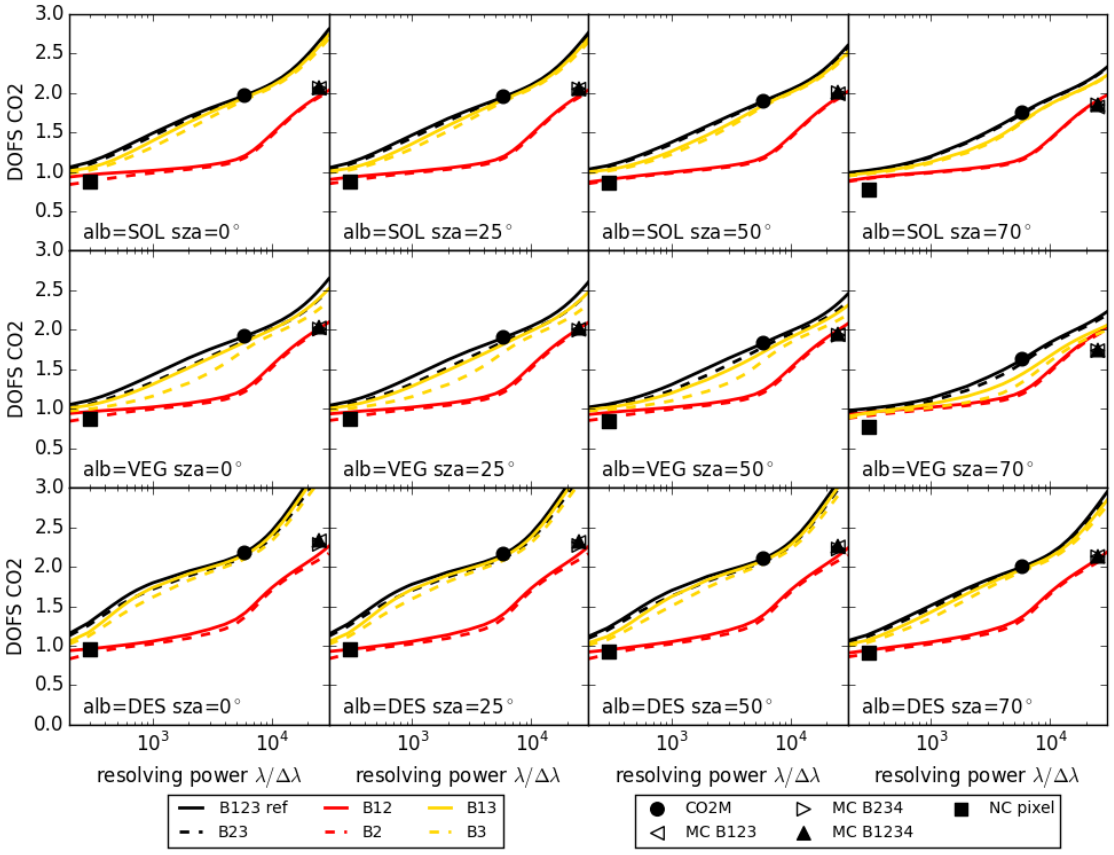

Figure S9. CO_2 degrees of freedom for the fictitious CVAR instrument, for resolving power $\lambda/\Delta\lambda$ evolving from 200 to 30000 (horizontal axis), and for different spectral band selections: with and without O_2 0.76 µm band (B1, full and dashed-lines, respectively), with both CO_2 1.6 and 2.05 µm bands (B23, black), with only the 1.6 µm band (B2, red) and with only the 2.05 µm band (B3, yellow), for SOL, VEG and DES albedo models (rows), and SZA values ranging from 0º to 70º (columns). Symbols give the same quantities for NanoCarb (NC, squares), MicroCarb (MC, triangles) and CO_2M (circle).

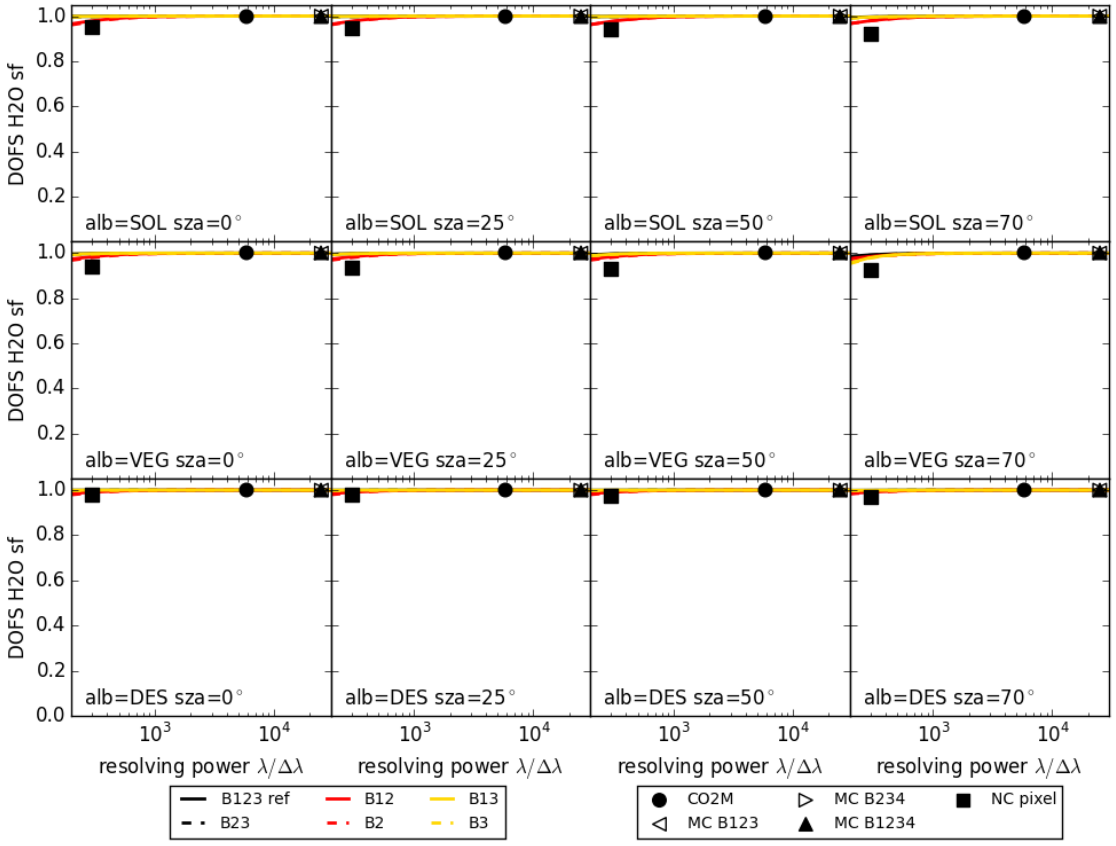

Figure S10. H_2O scaling factor degrees of freedom for the fictitious CVAR instrument, for resolving power $\lambda/\Delta\lambda$ evolving from 200 to 30000 (horizontal axis), and for different spectral band selections: with and without O_2 0.76 µm band (B1, full and dashed-lines, respectively), with both CO_2 1.6 and 2.05 µm bands (B23, black), with only the 1.6 µm band (B2, red) and with only the 2.05 µm band (B3, yellow), for SOL, VEG and DES albedo models (rows), and SZA values ranging from 0º to 70º (columns). Symbols give the same quantities for NanoCarb (NC, squares), MicroCarb (MC, triangles) and CO_2M (circle).

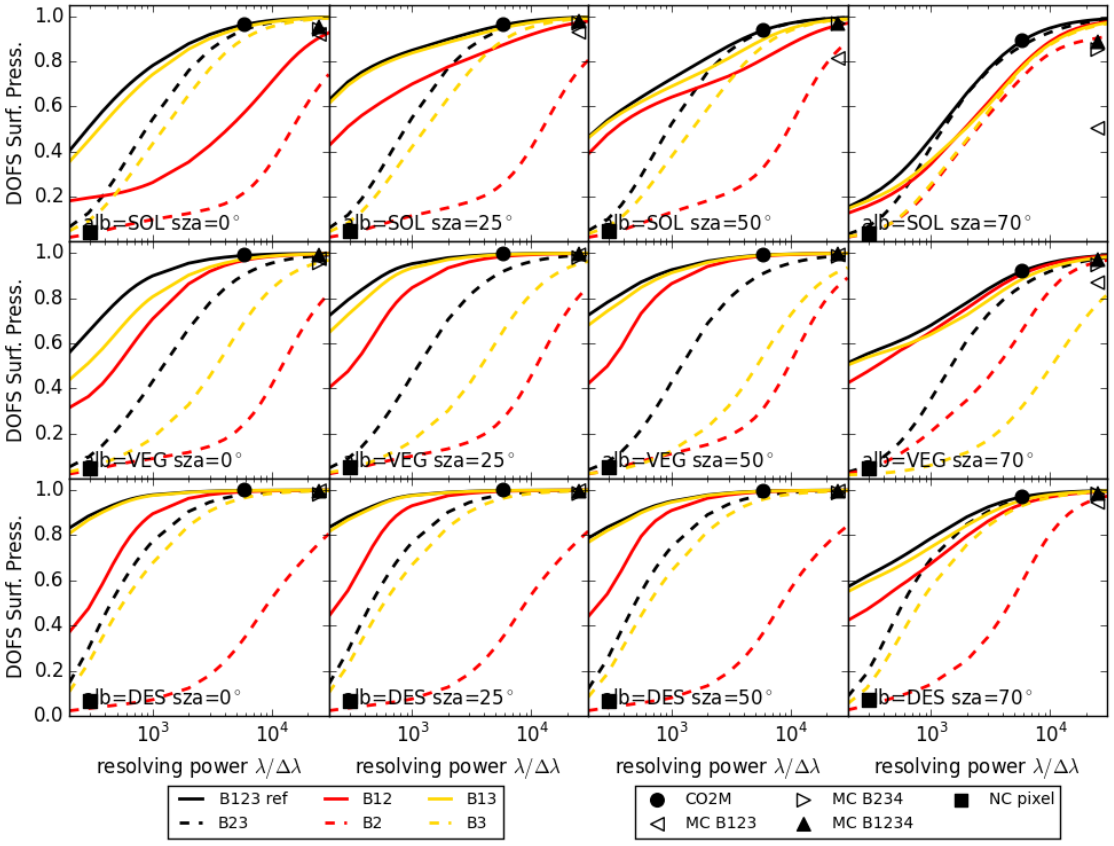

Figure S11. Surface Pressure degrees of freedom for the fictitious CVAR instrument, for resolving power $\lambda/\Delta\lambda$ evolving from 200 to 30000 (horizontal axis), and for different spectral band selections: with and without O_2 0.76 µm band (B1, full and dashed-lines, respectively), with both CO_2 1.6 and 2.05 µm bands (B23, black), with only the 1.6 µm band (B2, red) and with only the 2.05 µm band (B3, yellow), for SOL, VEG and DES albedo models (rows), and SZA values ranging from 0º to 70º (columns). Symbols give the same quantities for NanoCarb (NC, squares), MicroCarb (MC, triangles) and CO_2M (circle).

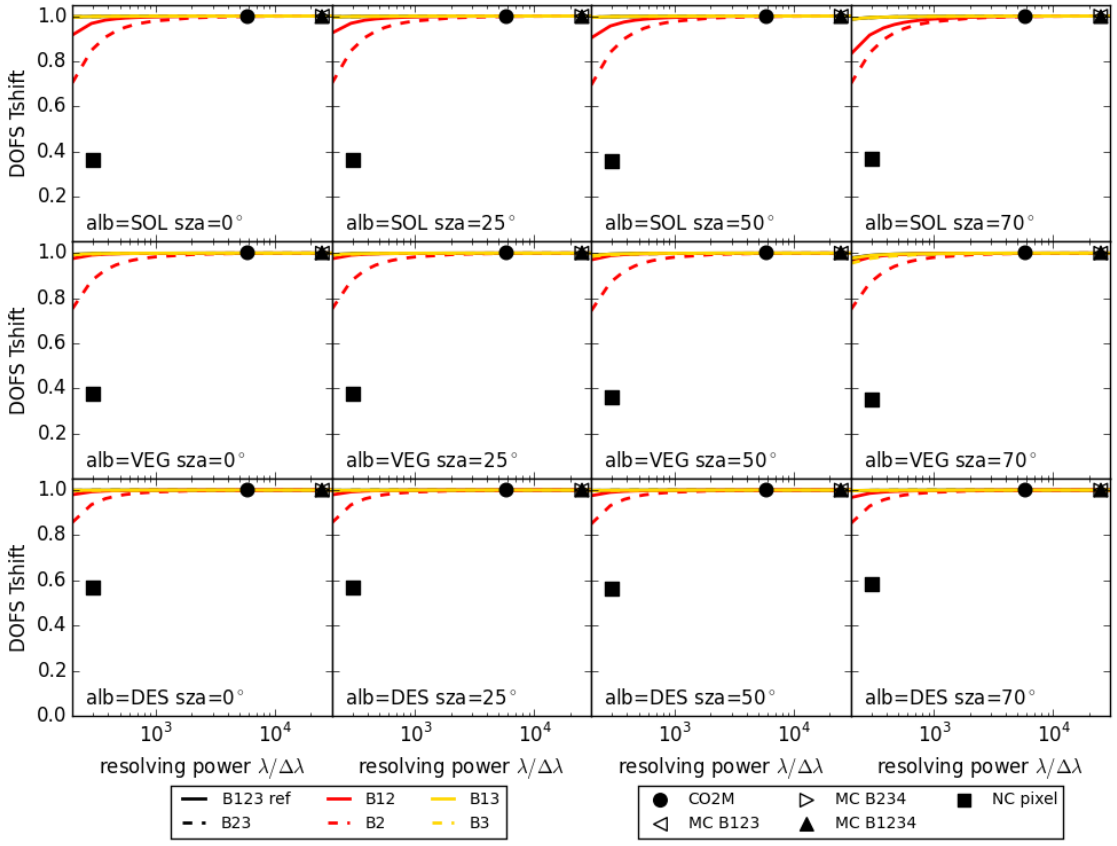

Figure S12. Temperature profile shift degrees of freedom for the fictitious CVAR instrument, for resolving power $\lambda/\Delta\lambda$ evolving from 200 to 30000 (horizontal axis), and for different spectral band selections: with and without O_2 0.76 µm band (B1, full and dashed-lines, respectively), with both CO_2 1.6 and 2.05 µm bands (B23, black), with only the 1.6 µm band (B2, red) and with only the 2.05 µm band (B3, yellow), for SOL, VEG and DES albedo models (rows), and SZA values ranging from 0º to 70º (columns). Symbols give the same quantities for NanoCarb (NC, squares), MicroCarb (MC, triangles) and CO_2M (circle).

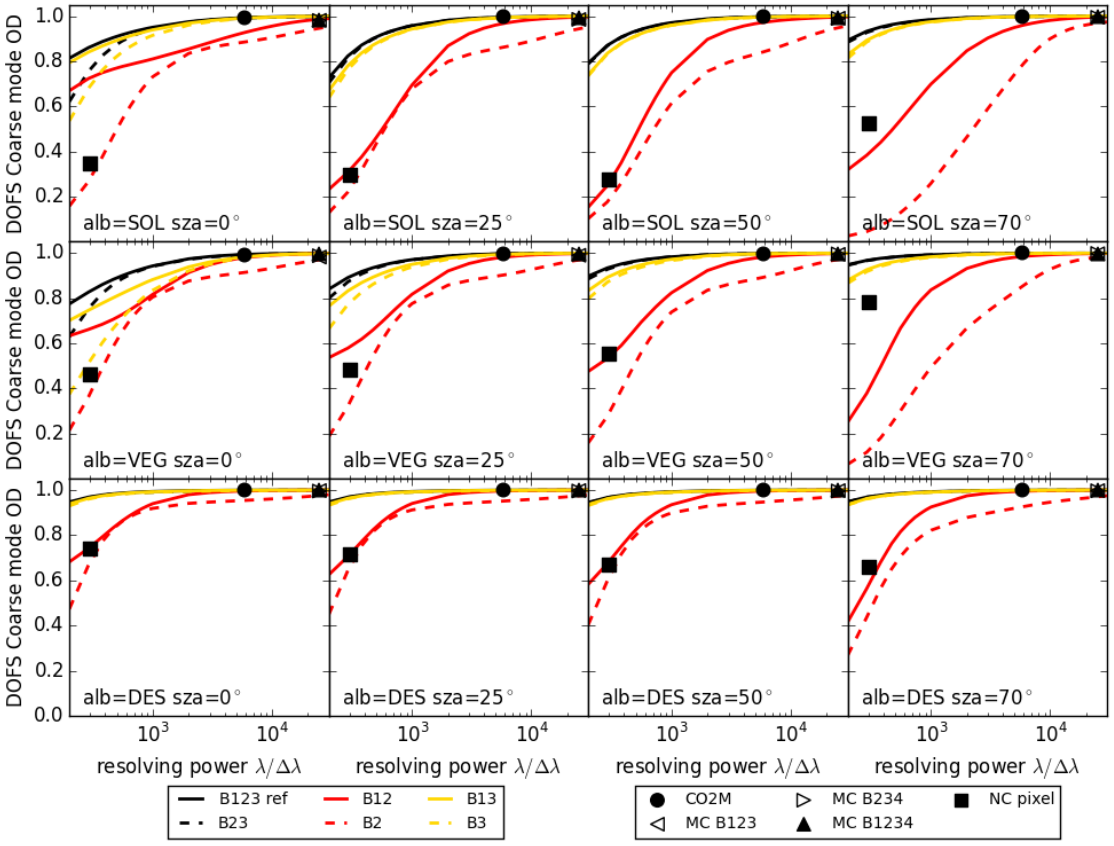

Figure S13. Coarse mode aerosol optical depth degrees of freedom for the fictitious CVAR instrument, for resolving power $\lambda/\Delta\lambda$ evolving from 200 to 30000 (horizontal axis), and for different spectral band selections: with and without O_2 0.76 µm band (B1, full and dashed-lines, respectively), with both CO_2 1.6 and 2.05 µm bands (B23, black), with only the 1.6 µm band (B2, red) and with only the 2.05 µm band (B3, yellow), for SOL, VEG and DES albedo models (rows), and SZA values ranging from 0º to 70º (columns). Symbols give the same quantities for NanoCarb (NC, squares), MicroCarb (MC, triangles) and CO_2M (circle).

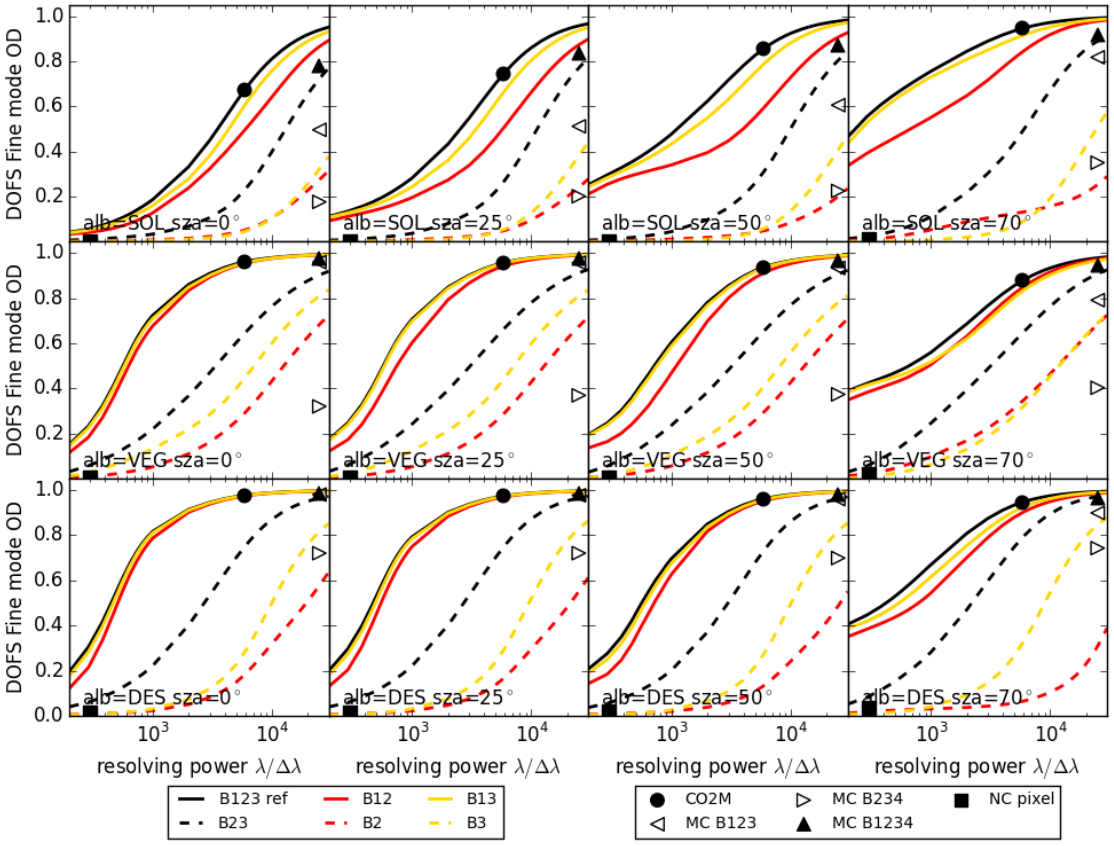

Figure S14. Fine mode aerosol optical depth degrees of freedom for the fictitious CVAR instrument, for resolving power $\lambda/\Delta\lambda$ evolving from 200 to 30000 (horizontal axis), and for different spectral band selections: with and without O_2 0.76 µm band (B1, full and dashed-lines, respectively), with both CO_2 1.6 and 2.05 µm bands (B23, black), with only the 1.6 µm band (B2, red) and with only the 2.05 µm band (B3, yellow), for SOL, VEG and DES albedo models (rows), and SZA values ranging from 0º to 70º (columns). Symbols give the same quantities for NanoCarb (NC, squares), MicroCarb (MC, triangles) and CO_2M (circle).

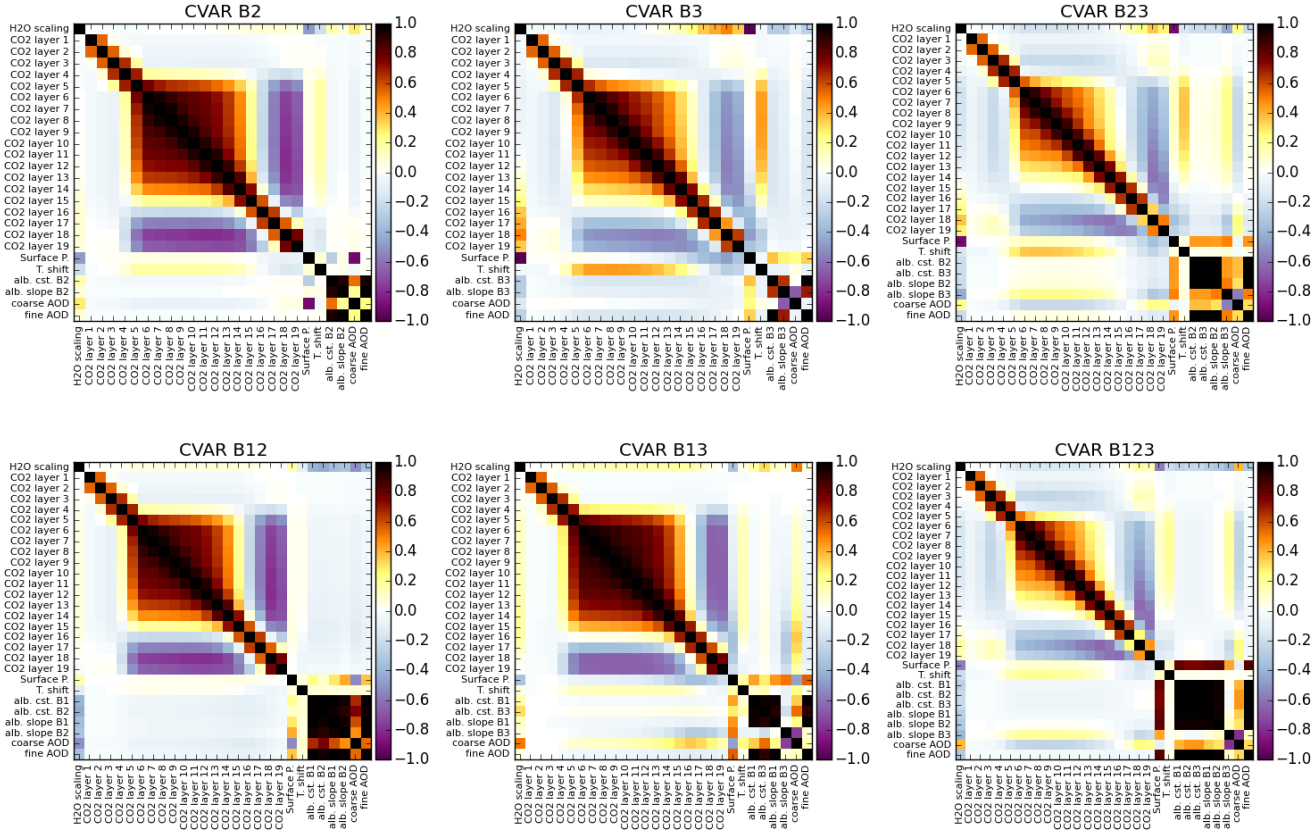

Figure S15. A posteriori correlation matrices for CVAR with a resolving power of 6000 for different spectral band combinations: without and with O_2 0.76 µm band (B1, top and bottom rows, respectively), with only the 1.6 µm band (B2/B13, left), with only the 2.05 µm band (B3/B13, center), with both CO_2 1.6 and 2.05 µm bands (B23/B123, right), for the VEG-50º situation.

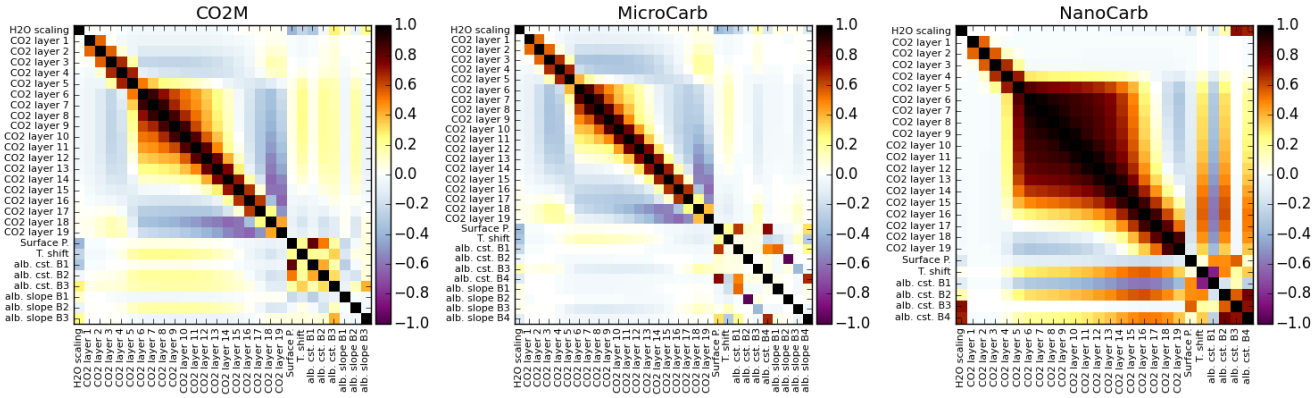

Figure S16. A posteriori correlation matrices for CO_2M (left), MicroCarb (center) and NanoCarb (right), for the VEG-50º situation, when aerosol optical depth parameters are removed from the state vector.

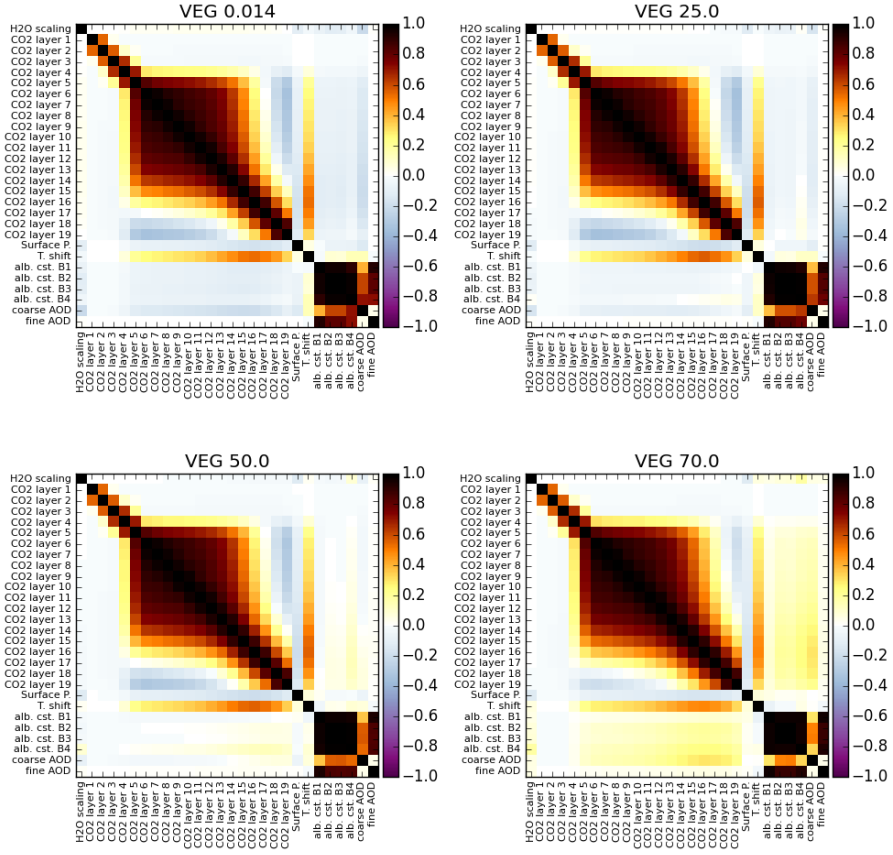

Figure S17. A posteriori correlation matrices for NanoCarb and different SZA values, for the VEG situations.

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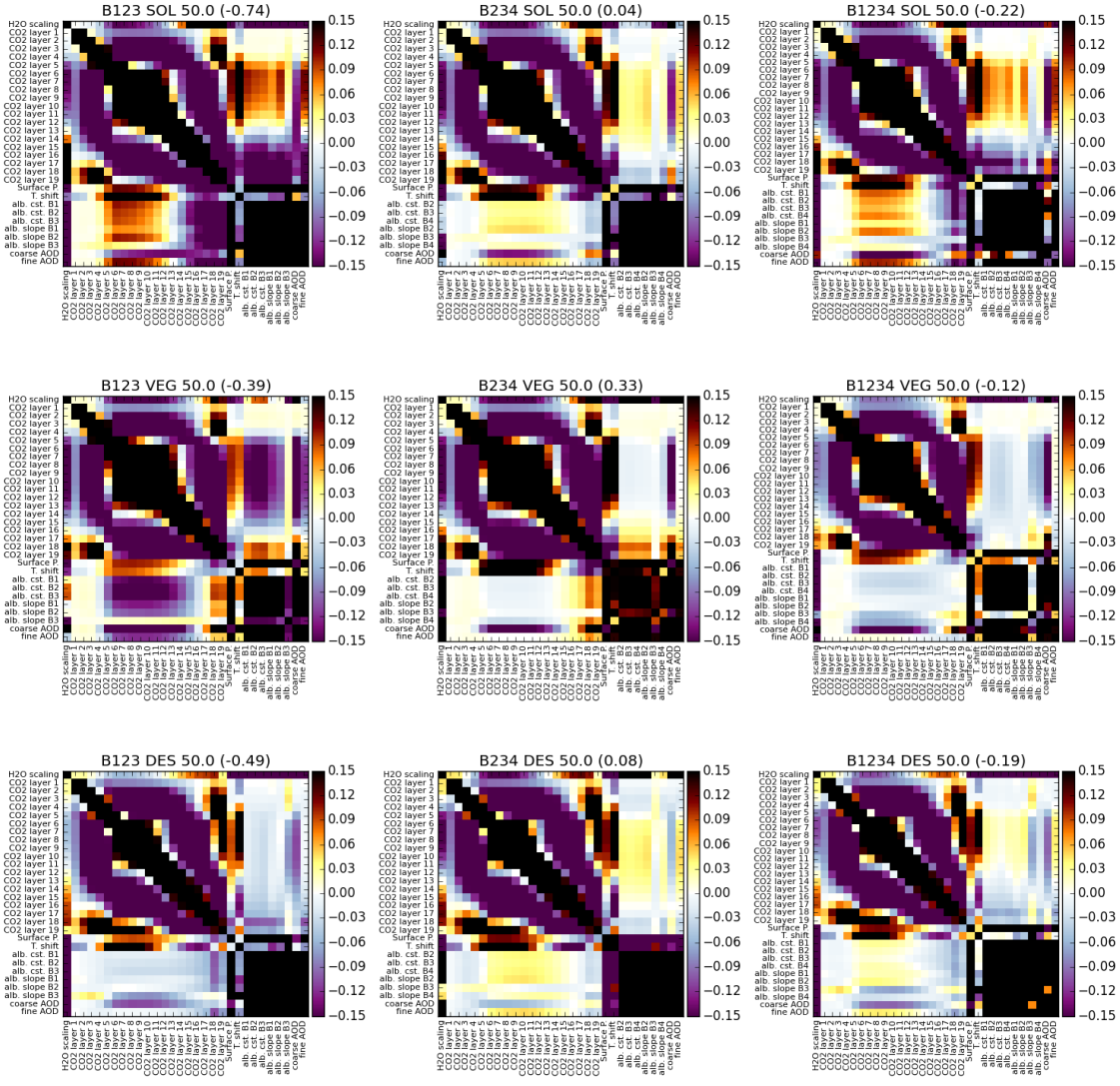

Figure S18. A posteriori correlation matrices for MicroCarb in three different band combination: B123 (left), B234 (center) and B1234 (left), for three different albedo models SOL (top), VEG (center) and DES (bottom), and for a SZA equal to 50º. The panel titles give in parenthesis the a posteriori Pearson correlation coefficient between X_{CO_2} and fine mode aerosol optical depth.