

Supplementary Material for Evaluating the value of CrIS shortwave infrared channels in atmospheric sounding retrievals

Table S1: Summary of the experiments discussed in this paper. Each experiment is defined by the CrIS bands used in the Regression and Optimal Estimation (O-E) retrieval steps. The CrIS instrument has three bands that span the infrared spectrum as follows: the longwave band (**LW**, 660–1095 cm^{-1} , 713 total channels), the midwave (**MW**, 1210–1750 cm^{-1} , 865 total channels) and the shortwave band (**SW**, 2155–2550 cm^{-1} , 633 total channels).

Experiments	Summary
LW+MW+SW	<ul style="list-style-type: none">- Regression coefficients calculated using all 2211 CrIS channels from the LW, MW and SW bands.- O-E retrieval of temperature, water vapor and surface parameters with channel subsets as specified in Table S2.- O-E retrieval of <u>all seven</u> trace gas species (O_3, CO_2, CO, CH_4, HNO_3, SO_2 and N_2O) with channel subsets as specified in Table S6.
LW+MW	<ul style="list-style-type: none">- Regression coefficients calculated using the 1578 CrIS channels from the LW and MW bands <u>only</u>. The 633 CrIS channels from the SW band were omitted.- O-E retrieval of temperature, water vapor and surface parameters with channel subsets as specified in Table S3.- O-E retrieval of <u>six</u> trace gas species (O_3, CO_2, CH_4, HNO_3, SO_2 and N_2O) with channel subsets as specified in Table S6. The retrieval of CO was omitted due to the lack of any channels sensitive to CO in the LW and MW bands (See Figure 2).
MW+SW	<ul style="list-style-type: none">- Regression coefficients calculated using the 1498 CrIS channels from the MW and SW bands <u>only</u>. The 713 CrIS channels from the LW band were omitted. Note: We built regression coefficients with and without non-LTE sensitive channels (2255.0–2383.0 cm^{-1}) but only show the regression retrieval results without non-LTE sensitive channels in the paper.- O-E retrieval of temperature, water vapor and surface parameters with channel subsets as specified in Table S4.- O-E retrieval of <u>four</u> trace gas species (CO, CH_4, SO_2 and N_2O) with channel subsets as specified in Table S6. The retrieval of O_3, CO_2 and HNO_3 were omitted due to the lack of any channels sensitive to these species in the MW and SW bands (See Figure 2).
LW+SW	<ul style="list-style-type: none">- Regression coefficients calculated using the 1346 CrIS channels from the LW and SW bands <u>only</u>. The 865 CrIS channels from the MW band were omitted.- O-E retrieval of temperature, water vapor and surface parameters with channel subsets as specified in Table S5.

	- O-E retrieval of <u>four</u> trace gas species (O ₃ , CO ₂ , CO and HNO ₃) with channel subsets as specified in Table S6 . The retrieval of CH ₄ , SO ₂ and N ₂ O were omitted due to the lack of any channels sensitive to these species in the LW and SW bands (See Figure 2).
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Table S2: The CrIS channel subsets for temperature (T_p), water vapor (H₂O_{vap}) and surface parameters (surface skin temperature, emissivity and reflectivity) that NUCAPS employs in its Optimal Estimation retrieval step. Channels are selected from the CrIS bands, namely the longwave (**LW**, 660–1095 cm⁻¹, 713 total channels), the midwave (**MW**, 1210–1750 cm⁻¹, 865 total channels) and the shortwave band (**SW**, 2155–2550 cm⁻¹, 633 total channels). This table summarizes the channels used in the baseline experiment that employed all available CrIS bands, **LW+MW+SW**. The shaded lists denote channels used during the second O-E retrieval of T_p.

Parameter	CrIS band	Infrared wavenumber [cm ⁻¹]
T _p	LW	666.250, 667.500, 668.750, 669.375, 670.000, 672.500, 681.250, 687.500, 688.750, 689.375, 690.000, 691.250, 692.500, 693.750, 695.000, 696.250, 697.500, 698.750, 699.375, 700.000, 701.250, 702.500, 703.750, 704.375, 706.250, 707.500, 708.750, 710.000, 711.250, 712.500, 715.625, 717.500, 718.130, 718.750, 720.000, 721.250, 721.875, 723.130, 723.750, 724.380, 726.250, 726.875, 727.500, 728.125, 731.875, 734.375, 735.000, 738.125, 740.000, 741.875, 743.125, 745.625, 747.500, 749.380, 779.380, 784.380, 794.375, 796.880, 798.130, 799.375, 800.625, 803.750, 815.000, 816.250, 826.875, 928.750, 945.000, 952.500
	MW	1398.75, 1406.25, 1471.88, 1476.25, 1498.10, 1555.63, 1559.38, 1700.00, 1730.00, 1732.50, 1733.75, 1736.25
	SW	2198.75, 2201.88, 2207.50, 2220.00, 2222.50, 2224.38, 2255.00, 2260.00, 2263.75, 2266.25, 2270.00, 2272.50, 2277.50, 2280.00, 2282.50, 2285.00, 2287.50, 2292.50, 2293.75, 2295.62, 2297.50, 2303.12, 2305.00, 2307.50, 2312.50, 2316.88, 2322.50, 2324.38, 2330.00, 2331.88, 2338.12, 2343.12, 2348.12, 2357.50, 2360.00, 2365.00, 2367.50, 2370.00, 2372.50, 2375.00, 2377.50, 2380.00, 2380.62, 2381.25, 2381.88, 2382.50, 2383.12, 2383.75, 2384.38, 2385.00, 2385.63, 2386.25, 2386.88, 2387.50, 2388.12, 2388.75, 2389.38, 2390.00, 2390.62, 2391.25, 2391.88, 2392.50, 2393.12, 2393.75, 2405.00, 2412.50
H ₂ O _{vap}	LW	779.380, 784.380, 794.375, 796.880, 798.130, 799.375, 800.625, 803.750, 815.000, 816.250, 826.875, 928.750, 945.000, 952.500, 1091.25
	MW	1213.13, 1310.00, 1315.00, 1320.00, 1330.63, 1335.00, 1345.00, 1357.50, 1367.50, 1381.88, 1384.38, 1386.88, 1393.75, 1395.00, 1397.50, 1398.75, 1400.00, 1401.25, 1403.13, 1406.25, 1407.50, 1410.00, 1412.50, 1415.00, 1416.25, 1417.50, 1421.88, 1424.38, 1426.25, 1427.50, 1428.75, 1430.00, 1435.00, 1438.13, 1442.50, 1468.13, 1471.88, 1476.25, 1498.13, 1555.63, 1559.38, 1575.00, 1585.63, 1605.00, 1685.63, 1700.00, 1730.00, 1732.50, 1733.75, 1736.25, 1745.00

Surf	LW	789.375, 790.625, 823.750, 833.750, 843.750, 845.000, 899.375, 901.875, 904.375, 907.500, 911.250, 912.500, 916.250, 920.000, 927.500, 933.750, 935.625, 937.500, 939.375, 943.125, 946.250, 951.875, 956.250, 957.500, 962.500, 968.750, 980.000, 985.000, 1093.13, 1095.00
	MW	1231.25, 1234.38
	SW	2461.88, 2463.13, 2464.38, 2465.00, 2470.63, 2472.50, 2476.25, 2481.25, 2485.00, 2486.88, 2488.75, 2490.63, 2492.50, 2495.00, 2496.88, 2498.13, 2499.38, 2501.25, 2503.75, 2505.63, 2507.50, 2510.00, 2513.75, 2516.88, 2518.75, 2521.25, 2523.13, 2525.00, 2527.50, 2531.88, 2535.63, 2540.00, 2541.88, 2543.13

Table S3: Same as Table S1 except for the LW+MW experiment. The shaded lists denote channels used during the second O-E retrieval of T_p .

Parameter	CrIS band	Infrared wavenumber [cm^{-1}]
T_p	LW	666.250, 667.500, 668.750, 669.375, 670.000, 672.500, 681.250, 687.500, 688.750, 689.375, 690.000, 691.250, 692.500, 693.750, 695.000, 696.250, 697.500, 698.750, 699.375, 700.000, 701.250, 702.500, 703.750, 704.375, 706.250, 707.500, 708.750, 710.000, 711.250, 712.500, 715.625, 717.500, 718.130, 718.750, 720.000, 721.250, 721.875, 723.130, 723.750, 724.380, 726.250, 726.875, 727.500, 728.125, 731.875, 734.375, 735.000, 738.125, 740.000, 741.875, 743.125, 745.625, 747.500, 749.380, 779.380, 784.380, 794.375, 796.880, 798.130, 799.375, 800.625, 803.750, 815.000, 816.250, 826.875, 928.750, 945.000, 952.500
	MW	1398.75, 1406.25, 1471.88, 1476.25, 1498.13, 1555.63, 1559.38, 1700.00, 1730.00, 1732.50, 1733.75, 1736.25
$\text{H}_2\text{O}_{\text{vap}}$	LW	779.380, 784.380, 794.375, 796.880, 798.130, 799.375, 800.625, 803.750, 815.000, 816.250, 826.875, 928.750, 945.000, 952.500, 1091.25
	MW	1213.13, 1310.00, 1315.00, 1320.00, 1330.63, 1335.00, 1345.00, 1357.50, 1367.50, 1381.88, 1384.38, 1386.88, 1393.75, 1395.00, 1397.50, 1398.75, 1400.00, 1401.25, 1403.13, 1406.25, 1407.50, 1410.00, 1412.50, 1415.00, 1416.25, 1417.50, 1421.88, 1424.38, 1426.25, 1427.50, 1428.75, 1430.00, 1435.00, 1438.13, 1442.50, 1468.13, 1471.88, 1476.25, 1498.13, 1555.63, 1559.38, 1575.00, 1585.63, 1605.00, 1685.63, 1700.00, 1730.00, 1732.50, 1733.75, 1736.25, 1745.00
Surf	LW	789.375, 790.625, 823.750, 833.750, 843.750, 845.000, 899.375, 901.875, 904.375, 907.500, 911.250, 912.500, 916.250, 920.000, 927.500, 933.750, 935.625, 937.500, 939.375, 943.125, 946.250, 951.875, 956.250, 957.500, 962.500, 968.750, 980.000, 985.000, 1093.13, 1095.00
	MW	1231.25, 1234.38

Table S4: Same as Table S1 except for the **MW+SW** experiments. The shaded lists denote channels used during the second O-E retrieval of T_p .

Parameter	CrIS band	Infrared wavenumber [cm^{-1}]
T_p	MW	1398.75, 1406.25, 1471.88, 1476.25, 1498.13, 1555.63, 1559.38, 1700.00, 1730.00, 1732.50, 1733.75, 1736.25
	SW	2198.75, 2201.88, 2207.50, 2220.00, 2222.50, 2224.38, 2255.00, 2260.00, 2263.75, 2266.25, 2270.00, 2272.500, 2277.5, 2280.00, 2282.50, 2285.00, 2287.50, 2292.50, 2293.75, 2295.62, 2297.50, 2303.12, 2305.00, 2307.50, 2312.50, 2316.88, 2322.50, 2324.38, 2330.00, 2331.88, 2338.12, 2343.12, 2348.12, 2357.50, 2360.00, 2365.00, 2367.50, 2370.00, 2372.50, 2375.00, 2377.50, 2380.00, 2380.62, 2381.25, 2381.88, 2382.50, 2383.12, 2383.75, 2384.38, 2385.00, 2385.63, 2386.25, 2386.88, 2387.50, 2388.12, 2388.75, 2389.38, 2390.00, 2390.62, 2391.25, 2391.88, 2392.50, 2393.12, 2393.75, 2405.00, 2412.50
$\text{H}_2\text{O}_{\text{vap}}$	MW	1213.13, 1310.00, 1315.00, 1320.00, 1330.63, 1335.00, 1345.00, 1357.50, 1367.50, 1381.88, 1384.38, 1386.88, 1393.75, 1395.00, 1397.50, 1398.75, 1400.00, 1401.25, 1403.13, 1406.25, 1407.50, 1410.00, 1412.50, 1415.00, 1416.25, 1417.50, 1421.88, 1424.38, 1426.25, 1427.50, 1428.75, 1430.00, 1435.00, 1438.13, 1442.50, 1468.13, 1471.88, 1476.25, 1498.13, 1555.63, 1559.38, 1575.00, 1585.63, 1605.00, 1685.63, 1700.00, 1730.00, 1732.50, 1733.75
Surf	MW	1231.25, 1234.38
	SW	2461.88, 2463.13, 2464.38, 2465.00, 2470.63, 2472.50, 2476.25, 2481.25, 2485.00, 2486.88, 2488.75, 2490.63, 2492.50, 2495.00, 2496.88, 2498.13, 2499.38, 2501.25, 2503.75, 2505.63, 2507.50, 2510.00, 2513.75, 2516.88, 2518.75, 2521.25, 2523.13, 2525.00, 2527.50, 2531.88, 2535.63, 2540.00, 2541.88, 2543.13

Table S5: Same as Table A.1 except for the **LW+SW** experiments. The shaded lists denote channels used during the second O-E retrieval of T_p .

Parameter	CrIS band	Infrared wavenumber [cm^{-1}]
T_p	LW	666.250, 667.500, 668.750, 669.375, 670.000, 672.500, 681.250, 687.500, 688.750, 689.375, 690.000, 691.250, 692.500, 693.750, 695.000, 696.250, 697.500, 698.750, 699.375, 700.000, 701.250, 702.500, 703.750, 704.375, 706.250, 707.500, 708.750, 710.000, 711.250, 712.500, 715.625, 717.500, 718.130, 718.750, 720.000, 721.250, 721.875, 723.130, 723.750, 724.380, 726.250, 726.875, 727.500, 728.125, 731.875, 734.375, 735.000, 738.125, 740.000, 741.875, 743.125, 745.625, 747.500, 749.380, 730.625, 744.375, 754.375, 776.875, 779.375, 784.375, 794.375, 796.880, 798.750, 799.375, 800.625, 803.125, 808.125, 814.375, 816.250, 827.500, 908.750, 948.125

	SW	2198.75, 2201.88, 2207.50, 2220.00, 2222.50, 2224.38, 2255.00, 2260.00, 2263.75, 2266.25, 2270.00, 2272.50, 2277.50, 2280.00, 2282.50, 2285.00, 2287.50, 2292.50, 2293.75, 2295.62, 2297.50, 2303.12, 2305.00, 2307.50, 2312.50, 2316.88, 2322.50, 2324.38, 2330.00, 2331.88, 2338.12, 2343.12, 2348.12, 2357.50, 2360.00, 2365.00, 2367.50, 2370.00, 2372.50, 2375.00, 2377.50, 2380.00, 2380.62, 2381.25, 2381.88, 2382.50, 2383.12, 2383.75, 2384.38, 2385.00, 2385.63, 2386.25, 2386.88, 2387.50, 2388.12, 2388.75, 2389.38, 2390.00, 2390.62, 2391.25, 2391.88, 2392.50, 2393.12, 2393.75, 2405.00, 2412.50
H ₂ O vap	LW	730.625, 744.375, 754.375, 776.875, 779.375, 784.375, 794.375, 796.880, 798.750, 799.375, 800.625, 803.125, 808.125, 814.375, 816.250, 827.500, 908.750, 948.125
Surf	LW	789.375, 790.625, 823.750, 833.750, 843.750, 845.000, 899.375, 901.875, 904.375, 907.500, 911.250, 912.500, 916.250, 920.000, 927.500, 933.750, 935.625, 937.500, 939.375, 943.125, 946.250, 951.875, 956.250, 957.500, 962.500, 968.750, 980.000, 985.000, 1093.13, 1095.00
	SW	2461.88, 2463.13, 2464.38, 2465.00, 2470.63, 2472.50, 2476.25, 2481.25, 2485.00, 2486.88, 2488.75, 2490.63, 2492.50, 2495.00, 2496.88, 2498.13, 2499.38, 2501.25, 2503.75, 2505.63, 2507.50, 2510.00, 2513.75, 2516.88, 2518.75, 2521.25, 2523.13, 2525.00, 2527.50, 2531.88, 2535.63, 2540.00, 2541.88, 2543.13

Table S6: Summary of channels used for seven trace gas species; Ozone (O₃), Carbon Dioxide (CO₂), Methane (CH₄), Nitric Acid (HNO₃), Carbon Monoxide (CO), Nitrous Oxide (N₂O) and Sulfur Dioxide(SO₂). The channels subsets are selected based on the spectral signatures as depicted in **Figure 2**.

Parameter	CrIS band	Infrared wavenumber [cm ⁻¹]
O ₃	LW	996.875, 997.500, 998.125, 999.380, 1000.00, 1000.63, 1001.88, 1002.50, 1003.13, 1005.00, 1005.63, 1007.50, 1008.13, 1010.00, 1011.88, 1012.50, 1013.13, 1014.38, 1015.00, 1015.63, 1016.25, 1016.88, 1018.13, 1018.75, 1019.38, 1020.00, 1020.63, 1021.25, 1021.88, 1022.50, 1023.13, 1023.75, 1024.38, 1025.00, 1025.63, 1026.25, 1026.88, 1028.75, 1031.25, 1031.88, 1032.50, 1033.13, 1033.75, 1034.38, 1035.00, 1035.63, 1036.25, 1036.88, 1037.50, 1038.13, 1038.75, 1040.63, 1041.25, 1041.88, 1045.63, 1047.50, 1048.13, 1049.38, 1050.00, 1050.63, 1051.25, 1051.88, 1053.13, 1053.75, 1054.38, 1055.63, 1056.25, 1056.88, 1057.50, 1058.13, 1058.75, 1060.00, 1060.63, 1061.25, 1063.75, 1066.25, 1068.13,
CO ₂	LW	666.250, 667.500, 668.750, 669.375, 670.000, 672.500, 681.250, 687.500, 688.750, 689.375, 690.000, 691.250, 692.500, 693.750, 695.000, 696.250, 697.500, 698.750, 699.375, 700.000, 701.250, 702.500, 703.750, 704.375, 706.250, 707.500, 708.750, 710.000, 711.250, 712.500, 715.625, 717.500, 718.130, 718.750, 720.000, 721.250, 721.875, 723.130, 723.750, 724.380, 726.250, 726.875, 727.500, 728.125, 731.875, 734.375, 735.000, 738.125, 740.000, 741.875, 743.125, 745.625, 747.500, 749.380,
CH ₄	MW	1220.00, 1228.75, 1229.38, 1230.00, 1236.25, 1237.50, 1238.75, 1241.25, 1242.50, 1245.63, 1246.25, 1246.88, 1247.50, 1250.00, 1252.50, 1253.13, 1253.75, 1255.00, 1256.25, 1260.00, 1261.25, 1261.88, 1262.50, 1263.13, 1263.75, 1265.00, 1265.63, 1267.50, 1268.13, 1268.75,

		1269.38, 1270.00, 1271.25, 1275.00, 1275.63, 1276.25, 1276.88, 1277.50, 1281.25, 1281.88, 1282.50, 1283.13, 1283.75, 1287.50, 1288.13, 1288.75, 1290.00, 1292.50, 1294.38, 1295.00, 1296.25, 1297.50, 1300.00, 1301.25, 1301.88, 1302.50, 1303.13, 1303.75, 1304.38, 1305.00, 1305.63, 1306.25, 1307.50, 1311.25, 1312.50, 1316.88, 1317.50, 1321.25, 1321.88, 1322.50, 1327.50, 1328.75, 1332.50, 1337.50, 1341.25, 1342.50, 1346.25, 1346.88, 1347.50, 1351.25, 1355.63, 1356.25, 1360.63, 1365.63
HNO ₃	LW	846.250, 847.500, 851.250, 855.625, 857.500, 858.125, 860.625, 861.875, 862.500, 867.500, 869.375, 873.125, 875.000, 876.875, 880.000, 881.875, 885.625, 893.125, 894.375, 895.625, 898.750, 900.000, 901.250, 902.500, 904.375, 907.500, 911.250, 912.500, 920.000, 923.125
CO	SW	2155.00, 2157.50, 2158.13, 2158.75, 2159.38, 2160.00, 2161.88, 2162.50, 2164.38, 2165.00, 2165.63, 2166.25, 2167.50, 2168.75, 2169.38, 2170.00, 2170.63, 2172.50, 2173.13, 2174.38, 2175.00, 2176.25, 2176.88, 2177.50, 2178.13, 2179.38, 2180.00, 2182.50, 2183.13, 2185.00, 2186.88, 2187.50, 2188.75, 2190.00, 2191.25
N ₂ O	MW	1274.38, 1275.00, 1275.63, 1276.25, 1276.88, 1277.50, 1278.13, 1278.75, 1279.38, 1281.88, 1282.50, 1285.00, 1285.63, 1291.88, 1292.50, 1295.63, 1296.25, 1298.13, 1298.75, 1299.38, 1300.63
SO ₂	MW	1345.00, 1350.00, 1352.50, 1354.38, 1357.50, 1358.75, 1359.38, 1360.00, 1360.63, 1361.25, 1361.88, 1362.50, 1367.50, 1370.00, 1370.63, 1371.25, 1371.88, 1372.50, 1374.38, 1375.00, 1375.63, 1376.25, 1376.88, 1377.50, 1379.38, 1380.00, 1381.88, 1382.50, 1383.75, 1384.38, 1385.00