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Atmospheric Infrared Sounder

AIRS V6 CO2 Retrieval Development

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AIRS Science Team Meeting, April 24-27, 2012

Activities – AIRS V6 CO2 Development

- **V6 PGE-compatible multi-layer CO2 Retrieval Code**

  Objective is to have a single post-processing CO2 retrieval PGE stripped of development and test code fragments capable of processing either V5 or V6 data to retrieve CO2 at one or more levels of the atmosphere independently.

- **Channel selection**

  Objective is to optimize channel subsets by analyzing their contribution functions over the globe using AIRS L2 retrievals for Jan/Apr/Jul/Oct of 2003/2007/2011 to better constrain the partial columns of the atmosphere which they represent.

- **V6 Testing**

  Initial test using V5 implementation

  L2 is from early V6 (V5.9.12 ZBT) – Jan/Apr/Jul/Oct 2003/2007/2011

  Currently implementing V6 RTA to support full V6 testing using V6.0.2 L2 data sets

AIRS V6 CO2 PGE Development

- V6 CO2 retrieval post-processing PGE reorganized for maintainability
  - Combines four separate research codes into one PGE
  - Legacy research code fragments and stubs removed
  - Code modularized and heavily commented
  - Implements both mid-trop and mid-strat capability
    - Common code modules
    - Switch between mid-trop and mid-strat by environmental variable controlling:
      - Channel lists
      - QA filtering rules
      - Priors
    - Validated that execution mode results in the same output as earlier runs of the four separate research codes
  - Allows easy addition of lower-trop capability
  - Supports choice of V5 or V6 RTA
    - Allows processing of V5 data as well as V6 data
    - Implements V6 Doppler/orbital/seasonal spectral shifts (new)
    - We learned a lot about V6 RTA while developing the Weighting Function and Contribution Function Tools

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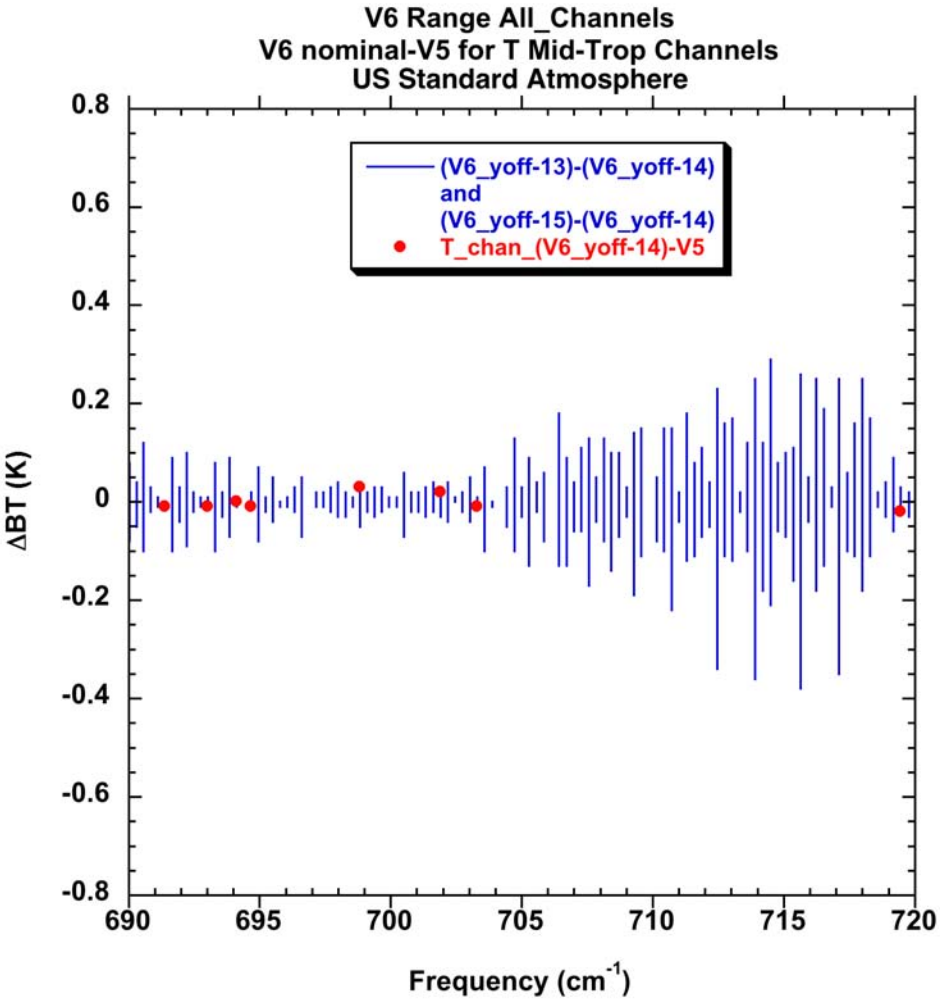
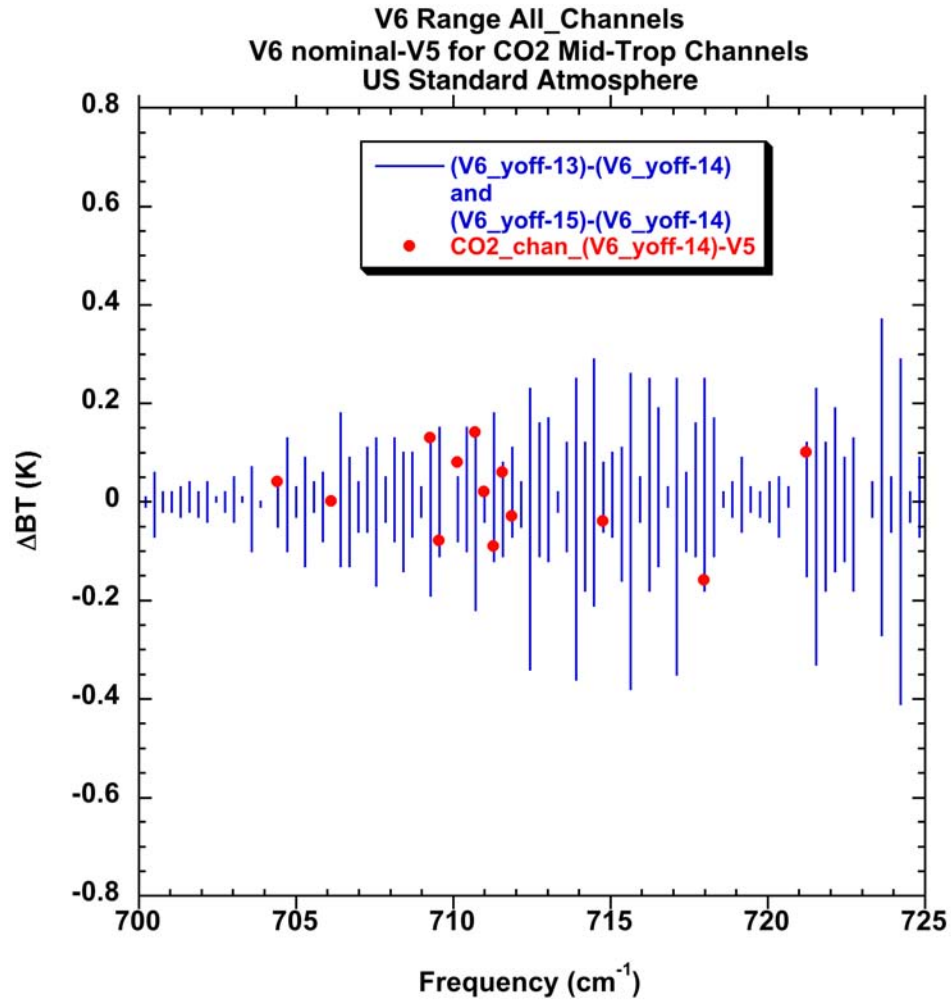
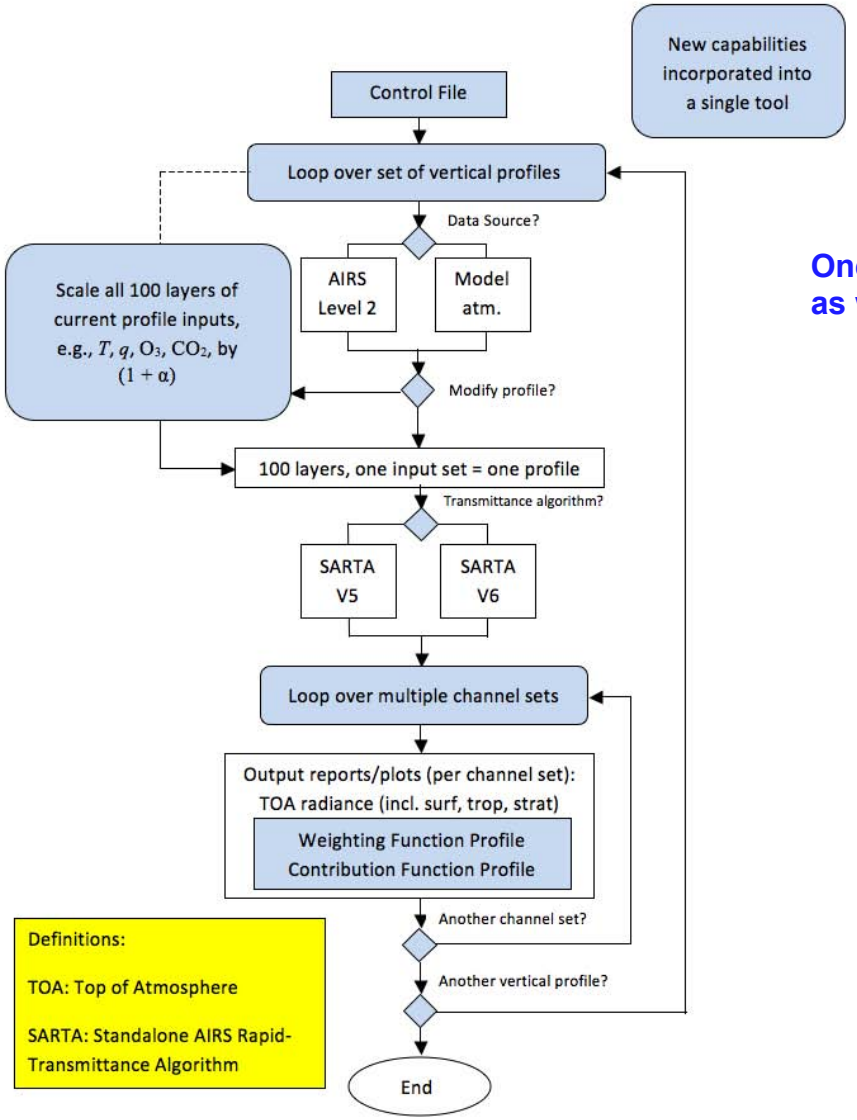
Expected V6 Spectral Shift Range and Offset of V5 from V6 Nominal Shift for VPD Mid-Trop Tair and CO2 Channels





Note:
Maximum spectral shift on the focal plane is expected to be ± 1 μm after adding up contributions of Doppler, orbital, seasonal and long-term contributions (1 μm ≈ 8.4 ppmf)

WgtFnc/CntFnc Tool Flow Diagram For Channel Selection Analysis



One of several tools developed as wrappers for V5 and V6 RTAs

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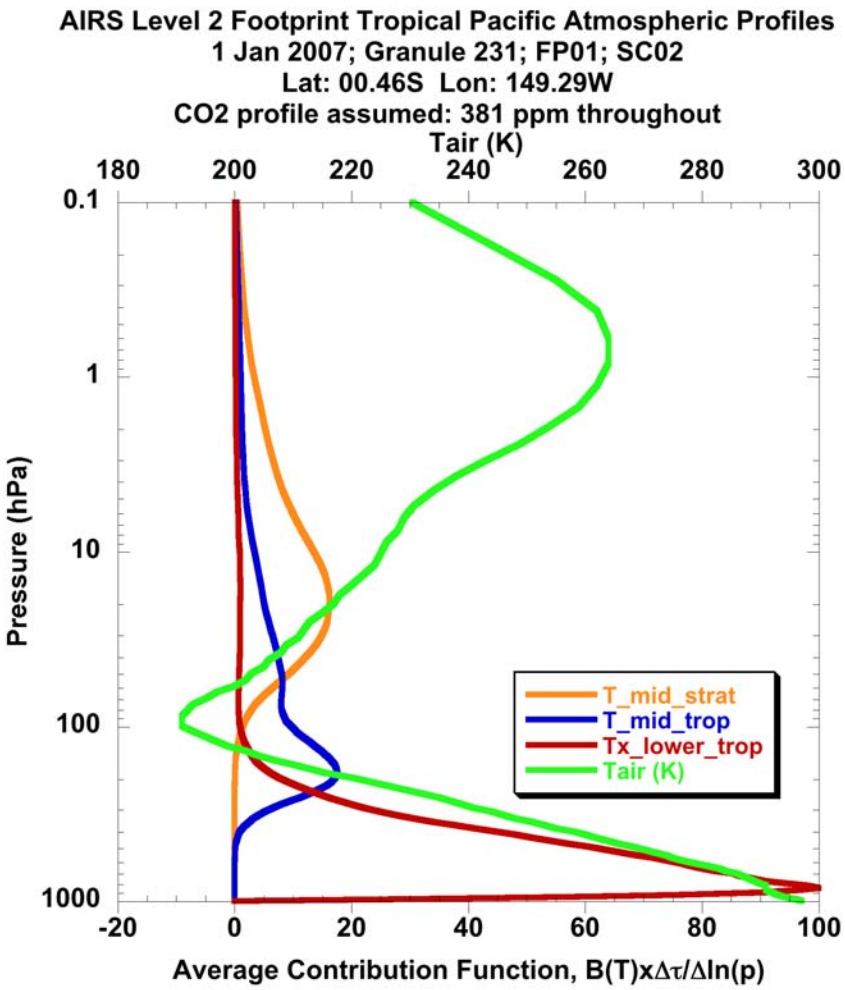
Example Report for AIRS L2 Arctic Footprint (Output profiles encompass all 100 layers)

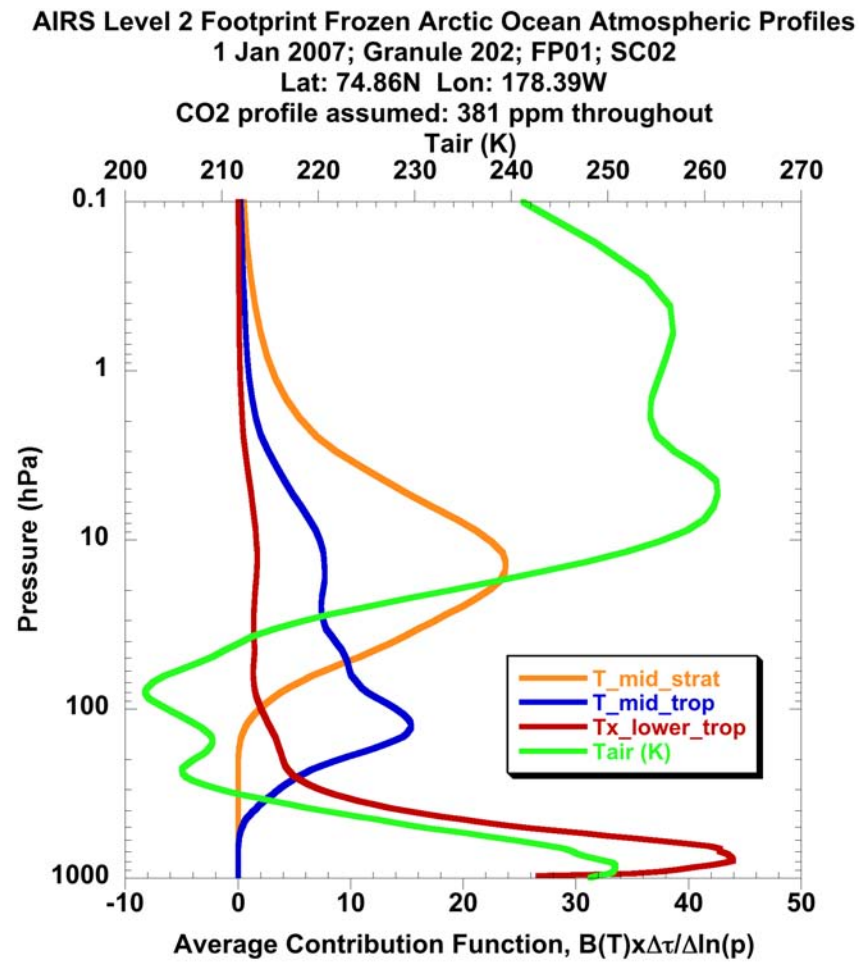
Output_Product_Name: cnt-2007-01-01_G202_FP01_SC02_v6_unperturbed-mid_trop_co2_ops-381ppm
Input_Instructions: /home/eto/WTG_TOOL/inputs/20070101_G202_Arctic/wtg_20070101_G202_co2_v6_unper.inp
SARTA_Library: /raid5/slicata/co2/wtg_sartav6/sartaV108_ext/lib/libsarta.so
Profile_Data_Source: /archive/AIRSOps/airs/gdaac/v5/2007/01/01/airx2sup/AIRS.2007.01.01.202.L2.RetSup.v5.0.14.0.G07193090333.hdf_Footprint[0-29]_01_Scanline[0-44]_02
Reference_Data_Source_(Observed): /archive/AIRSOps/airs/gdaac/v5/2007/01/01/airi2ccf/AIRS.2007.01.01.202.L2.CC.v5.0.14.0.G07193090333.hdf
Profile_Surface: PSurfStd_1008.85_mb_TSurfStd_248.04_K_LandFrac_0.00
Topography: Lat=74.86_deg_Lon=-178.39_deg_Elev=0.0_m_PGood=1008.85_mb_PBest=931.52_mb
Channel_Number_Set: mid_trop_co2_ops
Average_of_peak_pressure_levels_of_13_channels: 488.55
Standard_deviation_of_peak_pressure_of_13_channels: 58.48
Peak_pressure_of_the_curve_made_from_averages_of_13_channels: 487.21

CH_____:	X	X	X	192	198	209	210	212	214	215	216	217	218	228	239	250
cm-1_____:	X	X	X	704.44	706.14	709.28	709.57	710.14	710.72	711.00	711.29	711.58	711.87	714.77	717.99	721.24
TOA_obs_rad_____:	X	X	X	39.2500	40.5000	42.8750	43.7500	43.0000	42.1250	44.8750	43.3750	43.5000	43.7500	45.2500	47.2500	39.0000
TOA_obs_rad_err_:	X	X	X	0.1406	0.1250	0.2109	0.2422	0.1641	0.1562	0.2656	0.1797	0.2656	0.1875	0.2656	0.3281	0.1211
TOA_obs_Tb_K____:	X	X	X	216.87	218.51	221.54	222.54	221.77	220.86	223.92	222.31	222.48	222.79	224.74	227.21	218.47
TOA_obs_Tb_err_K_:	X	X	X	0.16	0.14	0.23	0.27	0.18	0.18	0.29	0.20	0.29	0.21	0.28	0.34	0.14
TOA_calc_rad____:	X	X	X	39.0579	40.2056	42.9581	43.4143	42.7110	42.3345	44.7162	43.3053	43.2927	43.2646	45.1995	46.9680	39.3267
TOA_calc_Tb_K___:	X	X	X	216.64	218.17	221.63	222.17	221.45	221.10	223.75	222.24	222.26	222.26	224.69	226.92	218.85
contrib_peak_mb_:	X	X	X	374.72	424.47	496.63	515.72	477.96	496.63	535.23	515.72	496.63	515.72	535.23	575.52	390.89
FWHM_mb_____:	X	X	X	423.32	394.95	411.25	411.03	407.27	564.66	425.19	432.06	428.30	426.75	447.07	469.28	489.87
surf_calc_rad___:	X	X	X	0.0001	0.0024	0.0407	0.0502	0.0306	0.0933	0.1932	0.0805	0.0547	0.0775	0.4484	0.8567	0.0845
surf_calc_Tb_K__:	X	X	X	58.57	70.71	88.30	89.97	86.25	95.28	102.24	94.04	90.83	93.77	112.03	120.88	95.41
trop_calc_rad___:	X	X	X	15.4037	21.2214	23.2184	23.9033	23.9303	18.9752	29.4923	22.4332	21.6559	24.0378	27.1782	29.7764	14.2032
trop_calc_Tb_K__:	X	X	X	180.88	192.01	195.68	196.80	196.91	188.59	205.22	194.64	193.39	197.29	202.38	206.43	180.33
strat_calc_rad__:	X	X	X	23.6542	18.9818	19.6990	19.4609	18.7501	23.2660	15.0307	20.7916	21.5821	19.1492	17.5729	16.3350	25.0390
strat_calc_Tb_K_:	X	X	X	195.80	188.06	189.73	189.34	188.11	195.92	180.89	191.88	193.26	189.05	186.46	184.41	199.94

layer	pressure	T_Air_K	theta	cnt	cnt	cnt	cnt	cnt	cnt	cnt	cnt	cnt	cnt	cnt	cnt	cnt	cnt_avg
000	1085.3611	-9.99900E+03	0.000E+00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
001	1056.4771	-9.99900E+03	0.000E+00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
002	1027.9924	-9.99900E+03	0.000E+00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
003	999.9099	2.48143E+02	2.470E+02	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
004	972.2318	2.48838E+02	2.491E+02	0.0000	0.0506	0.5488	0.6704	0.4258	0.9461	1.9509	0.8668	0.6517	0.9086	2.9736	5.2100	0.4790	1.2063
005	944.9604	2.50063E+02	2.526E+02	0.0000	0.1008	0.9350	1.1346	0.7451	1.5001	3.0922	1.4044	1.0901	1.5067	4.4276	7.6075	0.7040	1.8652
006	918.0980	2.50566E+02	2.557E+02	0.0000	0.1701	1.3332	1.6068	1.0934	1.9817	4.0881	1.9050	1.5217	2.0836	5.4920	9.2568	0.8598	2.4148
007	891.6464	2.50647E+02	2.578E+02	0.0303	0.2750	1.8335	2.1936	1.5454	2.5340	5.2282	2.4996	2.0496	2.7804	6.6227	10.7815	1.0263	3.0308
008	865.6077	2.50788E+02	2.602E+02	0.0550	0.4353	2.4840	2.9488	2.1426	3.2018	6.6009	3.2398	2.7109	3.6469	7.9414	12.5613	1.2198	3.7837
009	839.9835	2.50819E+02	2.625E+02	0.0978	0.6755	3.3292	3.9193	2.9205	4.0148	8.2696	4.1699	3.5563	4.7346	9.4585	14.6152	1.4631	4.7096
010	814.7755	2.50488E+02	2.647E+02	0.1688	1.0237	4.3913	5.1239	3.9084	4.9691	10.2200	5.2968	4.5897	6.0412	11.2169	16.8641	1.7520	5.8128
011	789.9849	2.49611E+02	2.664E+02	0.2807	1.5041	5.6474	6.5286	5.1197	6.0210	12.3498	6.5752	5.7744	7.5245	13.0775	19.0766	2.0898	7.0438
012	765.6133	2.48528E+02	2.675E+02	0.4471	2.1284	7.0337	8.0530	6.4596	7.1031	14.5061	7.9263	7.0903	9.0869	14.8652	21.0188	2.4530	8.3209
013	741.6616	2.47651E+02	2.689E+02	0.6923	2.9467	8.6275	9.7836	8.0141	8.2944	16.8337	9.4339	8.5398	10.8263	16.7523	22.9690	2.8874	9.7385
014	718.1309	2.46792E+02	2.705E+02	1.0472	4.0079	10.4909	11.7789	9.8538	9.6330	19.4111	11.1655	10.2155	12.8638	18.8292	25.1163	3.4162	11.3715
015	695.0221	2.46288E+02	2.720E+02	1.5361	5.3120	12.5246	13.9266	11.8932	11.0282	22.0304	13.0085	12.0196	14.9640	20.9330	27.1909	4.0334	13.1077
016	672.3358	2.45601E+02	2.745E+02	2.2415	7.0409	15.0770	16.6012	14.4296	12.7693	25.2698	15.3285	14.2801	17.5727	23.6214	29.9937	4.8646	15.3146
017	650.0724	2.44148E+02	2.756E+02	3.1208	8.9577	17.5051	19.0899	16.9170	14.3239	28.0340	17.4689	16.3886	19.9299	25.8659	32.1166	5.7172	17.3412
018	628.2324	2.42572E+02	2.765E+02	4.1722	10.9725	19.6727	21.2626	19.1967	15.6398	30.1754	19.2995	18.2463	21.9256	27.5346	33.3270	6.6161	19.0801
019	606.8161	2.40953E+02	2.774E+02	5.4238	13.1354	21.7293	23.2767	21.4047	16.8676	32.0179	21.0156	19.8892	23.7580	28.9714	34.2134	7.6608	20.7203
020	585.8234	2.39197E+02	2.783E+02	6.8647	15.3722	23.5993	25.0674	23.4579	17.9691	33.5025	22.5596	21.4682	25.3576	30.1130	34.7637	8.7582	22.2195
021	565.2542	2.37333E+02	2.790E+02	8.4233	17.5358	25.1119	26.4581	25.1833	18.8343	34.4345	23.7871	22.7494	26.4335	30.8304	34.7860	9.8584	23.4174
022	545.1084	2.35416E+02	2.796E+02	10.0807	19.5872	26.2866	27.4873	26.5842	19.5176	34.9010	24.7254	23.7830	27.2861	31.1914	34.4112	10.9341	24.3674
023	525.3855	2.33404E+02	2.802E+02	11.7702	21.4468	27.0888	28.1253	27.6152	20.0000	34.9255	25.3569	24.4603	27.7771	31.1920	33.6732	11.9765	25.0314
024	506.0849	2.31355E+02	2.807E+02	13.3974	22.9919	27.4396	28.3098	28.1859	20.2086	34.4429	25.6013	24.7867	27.8481	30.7568	32.5164	12.9286	25.3395
025	487.2058	2.29423E+02	2.813E+02	14.9373	24.2354	27.4431	28.1506	28.3888	20.2565	33.6020	25.5550	24.8333	27.6115	30.0170	31.1123	13.7807	25.3787
026	468.7474	2.27646E+02	2.821E+02	16.4145	25.2797	27.2784	27.7929	28.4005	20.2326	32.6404	25.3902	24.7536	27.2412	29.1848	29.7151	14.6038	25.3021
027	450.7087	2.25923E+02	2.831E+02	17.7817	26.1003	26.9527	27.3298	28.2341	20.1445	31.5665	25.1110	24.5489	26.7497	28.2770	28.3293	15.3911	25.1167
028	433.0883	2.24170E+02	2.841E+02	18.9543	26.6036	26.3847	26.6442	27.7945	19.9055	30.2893	24.6370	24.1403	26.0567	27.1942	26.8364	16.0159	24.7274
029	415.8850	2.22357E+02	2.851E+02	19.8489	26.7049	25.5415	25.6966	27.0389	19.5300	28.7739	23.9209	23.4883	25.1218	25.8911	25.1907	16.4846	24.0948
030	399.0971	2.20513E+02	2.861E+02	20.4199	26.4550	24.4278	24.4998	25.9821	18.9851	27.0440	22.9630	22.5914	23.9572	24.3780	23.4622	16.7362	23.2232
031	382.7230	2.18714E+02	2.871E+02	20.7113	25.8667	23.1418	23.1456	24.7127	18.3065	25.2089	21.8409	21.5275	22.6512	22.7462	21.6162	16.7844	22.1738
032	366.7607	2.16994E+02	2.883E+02	20.7549	25.0718	21.7961	21.7448	23.3546	17.6295	23.3872	20.6601	20.3953	21.3089	21.1106	19.8321	16.7122	21.0583
033	351.2082	2.15330E+02	2.896E+02	20.5837	24.1058	20.4247	20.3295	21.9465	16.8767	21.6077	19.4521	19.2246	19.9575	19.5059	18.1372	16.5222	19.8980
034	336.0634	2.13674E+02	2.910E+02	20.1850	22.9733	19.0309	18.8987	20.4923	16.0782	19.8696	18.2077	18.0133	18.5964	17.9330	16.4700	16.2118	18.6892
035	321.3239	2.12019E+02	2.924E+02	19.5837	21.6905	17.6045	17.4420	18.9837	15.2241	18.1528	16.9229	16.7514	17.2128	16.3648	14.9479	15.7411	17.4325
036	306.9871	2.10503E+02	2.939E+02	18.7909	20.3177	16.1834	15.9943	17.4645	14.3378	16.4905	15.6264	15.4735	15.8411	14.8355	13.4506	15.1512	16.1506
037	293.0504	2.09179E+02	2.958E+02	17.9957	19.0247	14.9764	14.7031	16.0984	13.5441	15.0354	14.4742	14.3308	14.6215	13.5108	12.1629	14.5874	15.0050
038	279.5108	2.08042E+02	2.980E+02	17.1838	17.7788	13.8463	13.5305	14.8463	12.8051	13.7343	13.4264	13.2834	13.5124	12.3286	11.0456	14.0220	13.9495

Contribution Functions/Temperature Profiles V5 VPD T_{air} Auxiliary Groups using V6 RTA





Mid-Trop channel set at high latitude likely requires optimization

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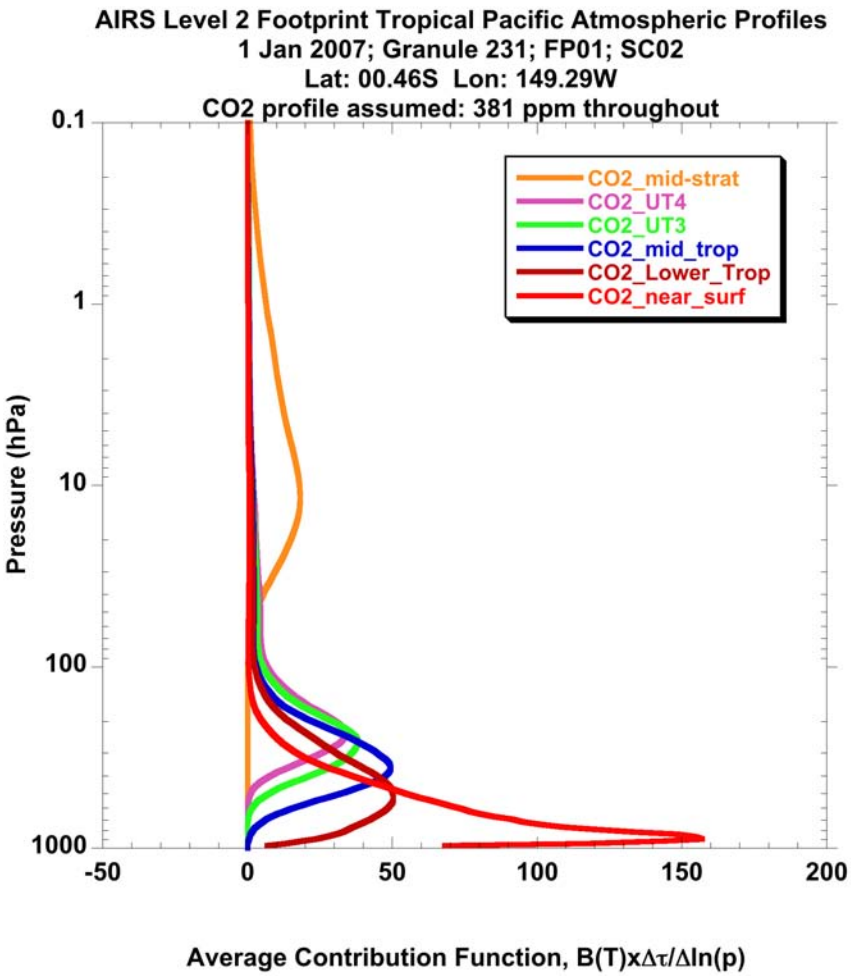
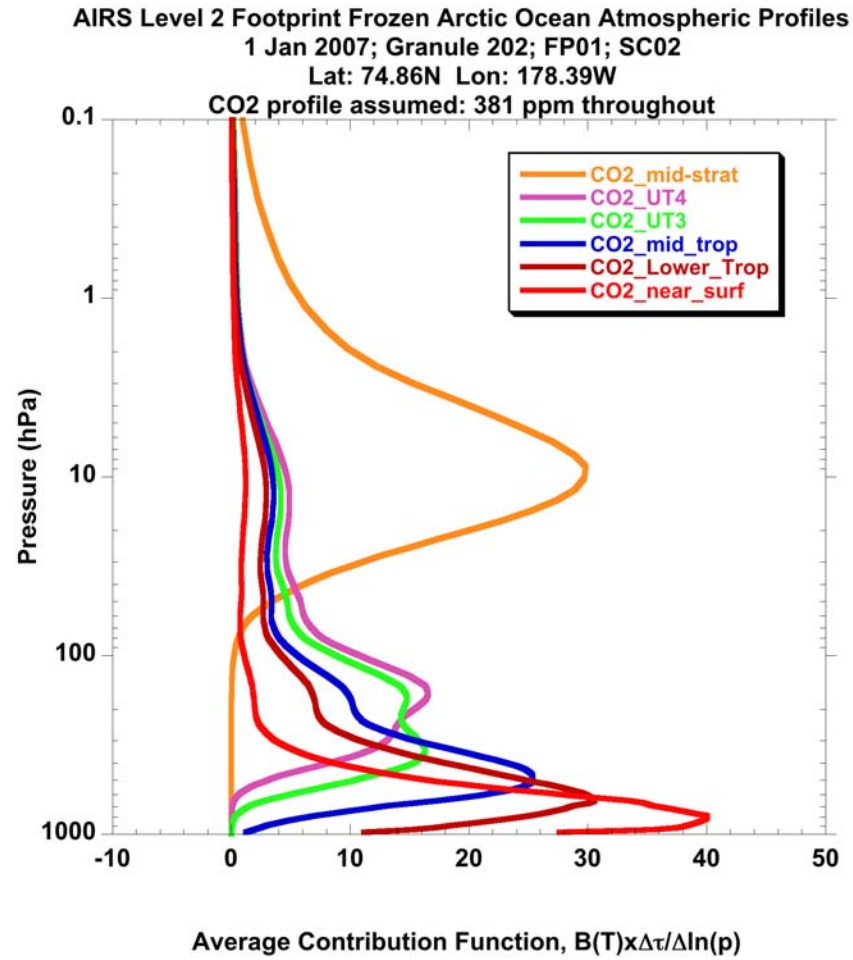
Contribution Functions/Temperature Profiles V5 VPD CO2 Groups using V6 RTA





Mid-Trop/Upper-Trop channel sets at high latitude likely require optimization

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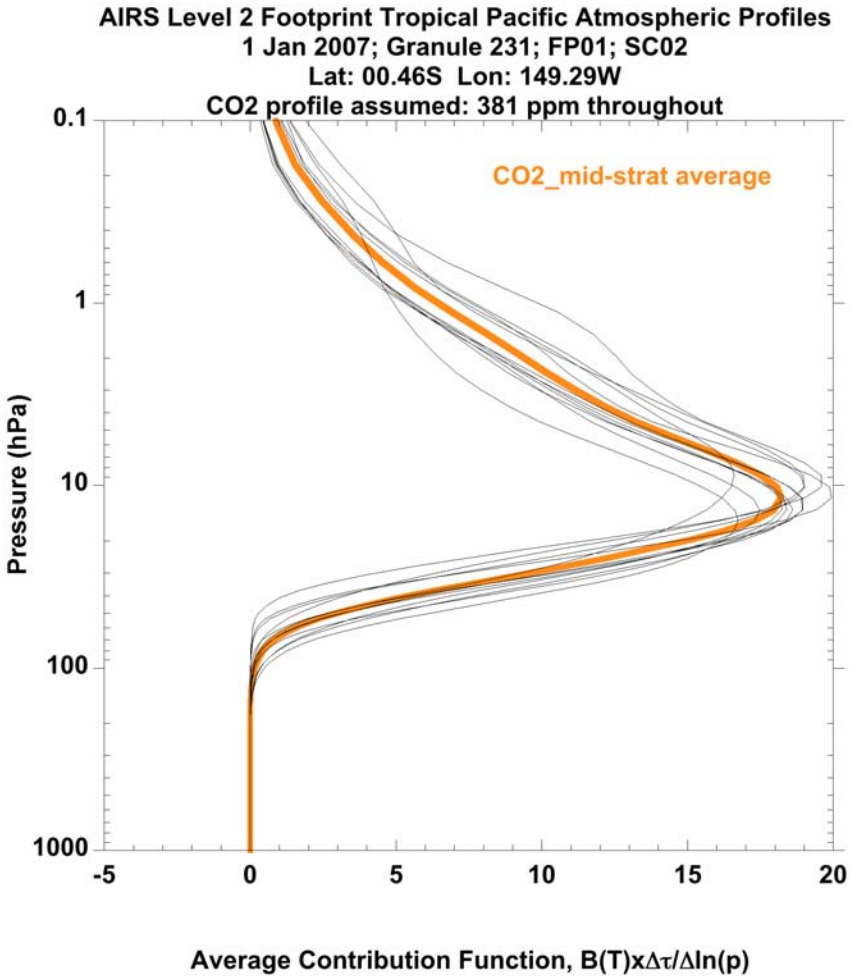
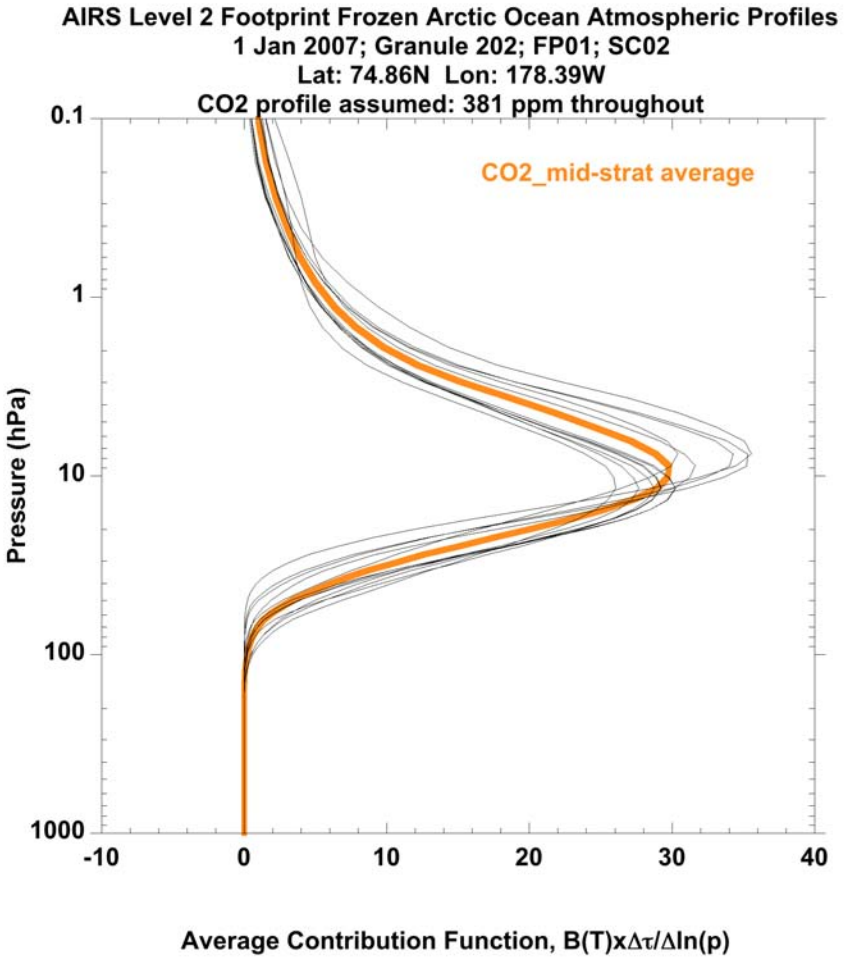
Contribution Functions
Initial CO2 Mid-Strat Channel Set using V6 RTA





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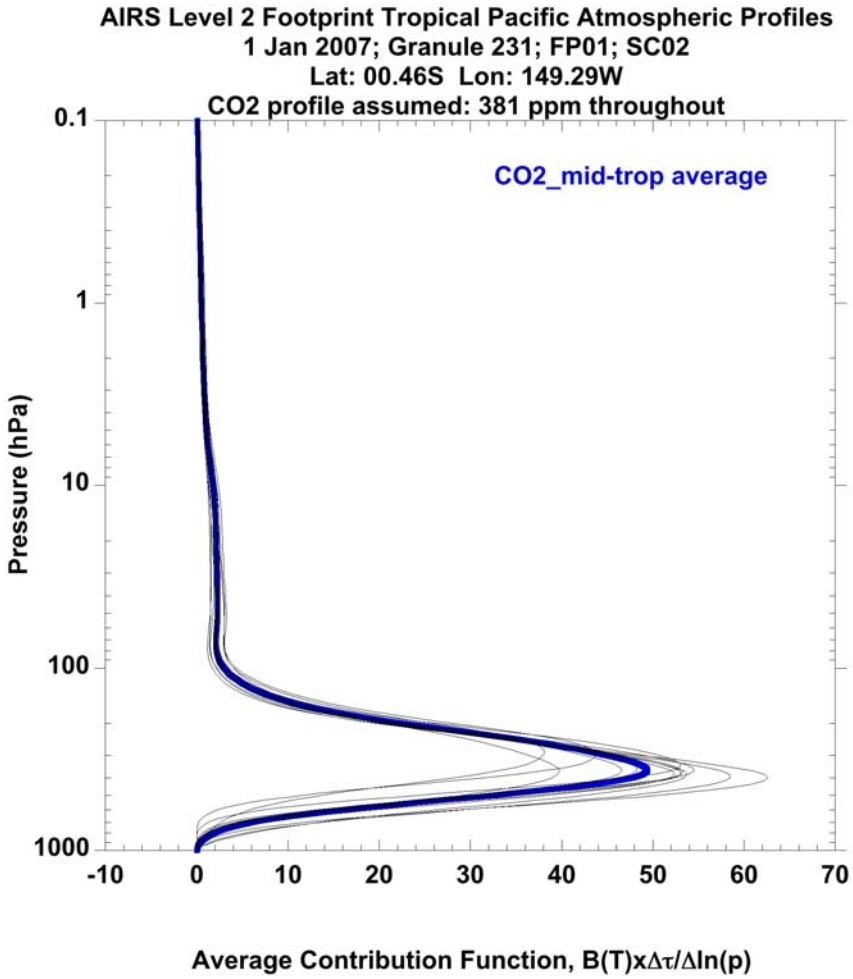
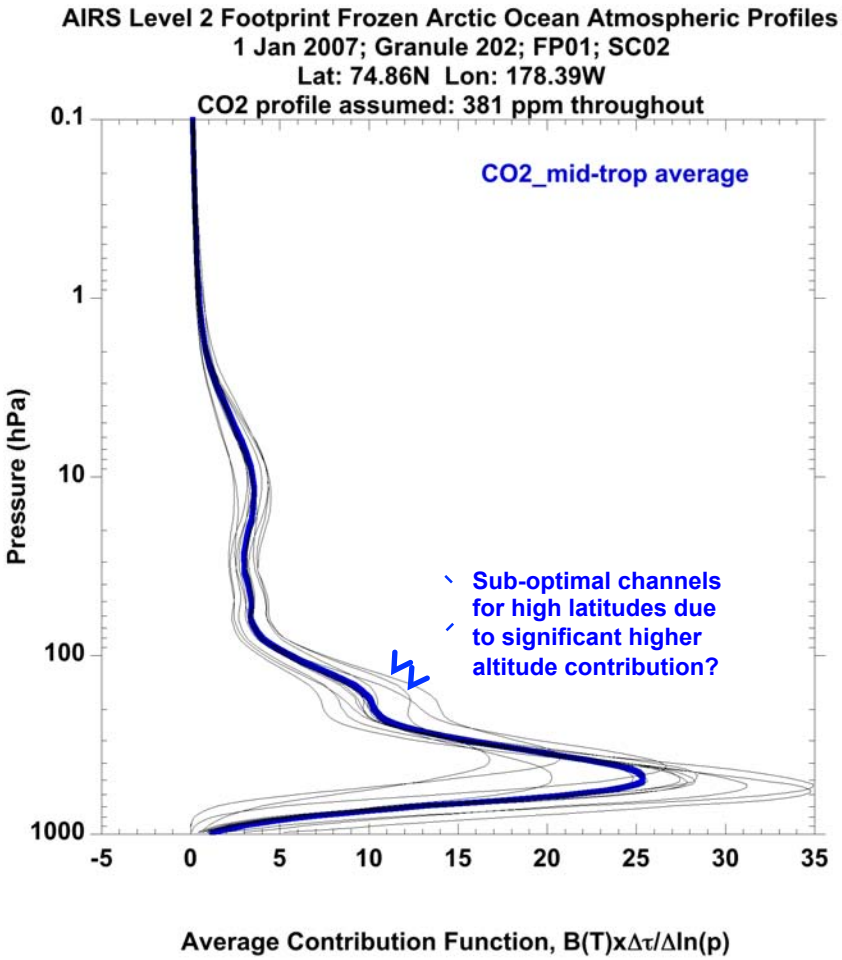
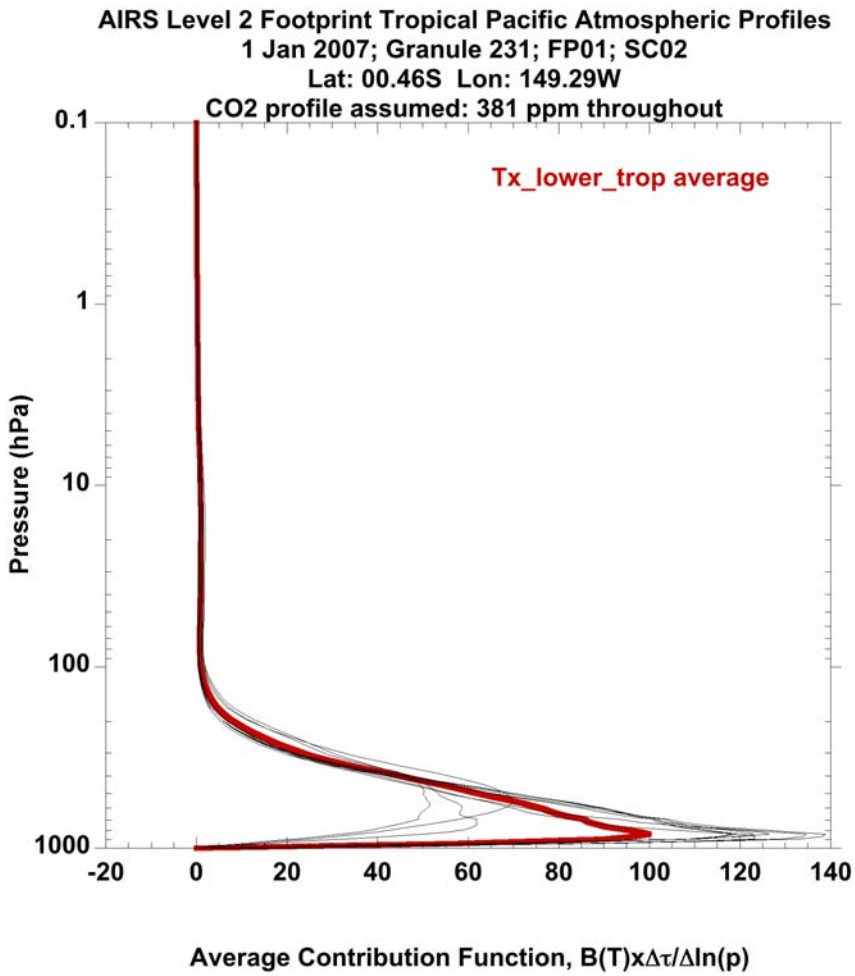
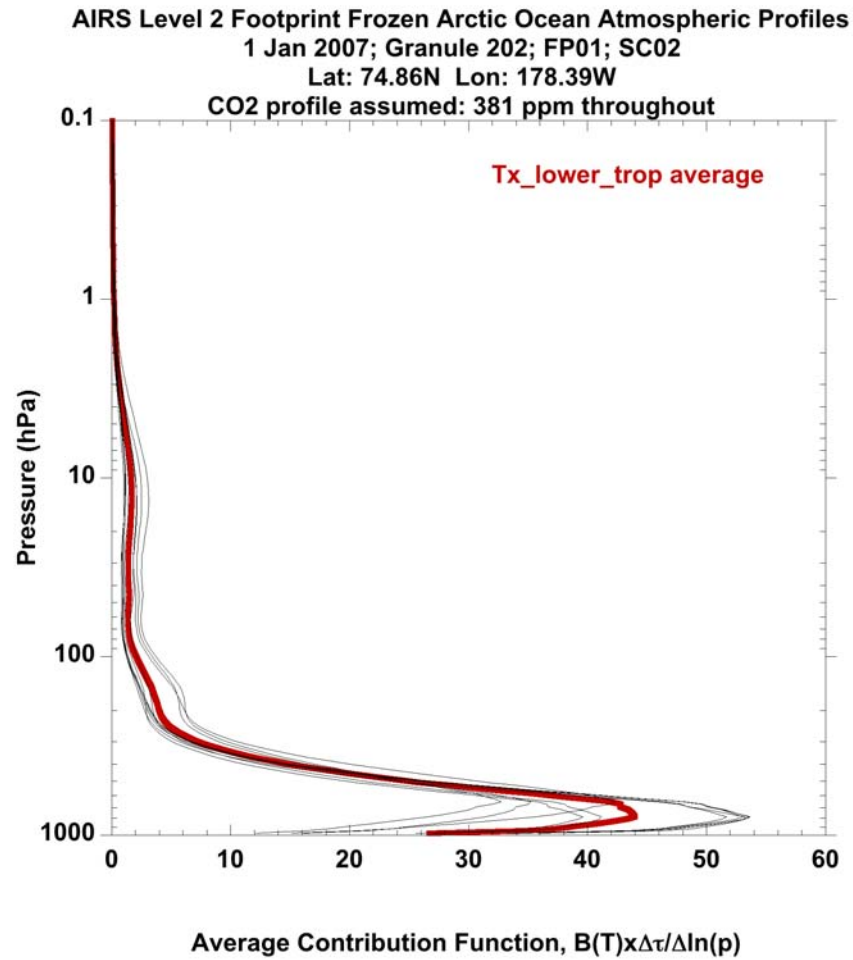
Contribution Functions
Initial CO2 Mid-Trop Channel Set using V6 RTA



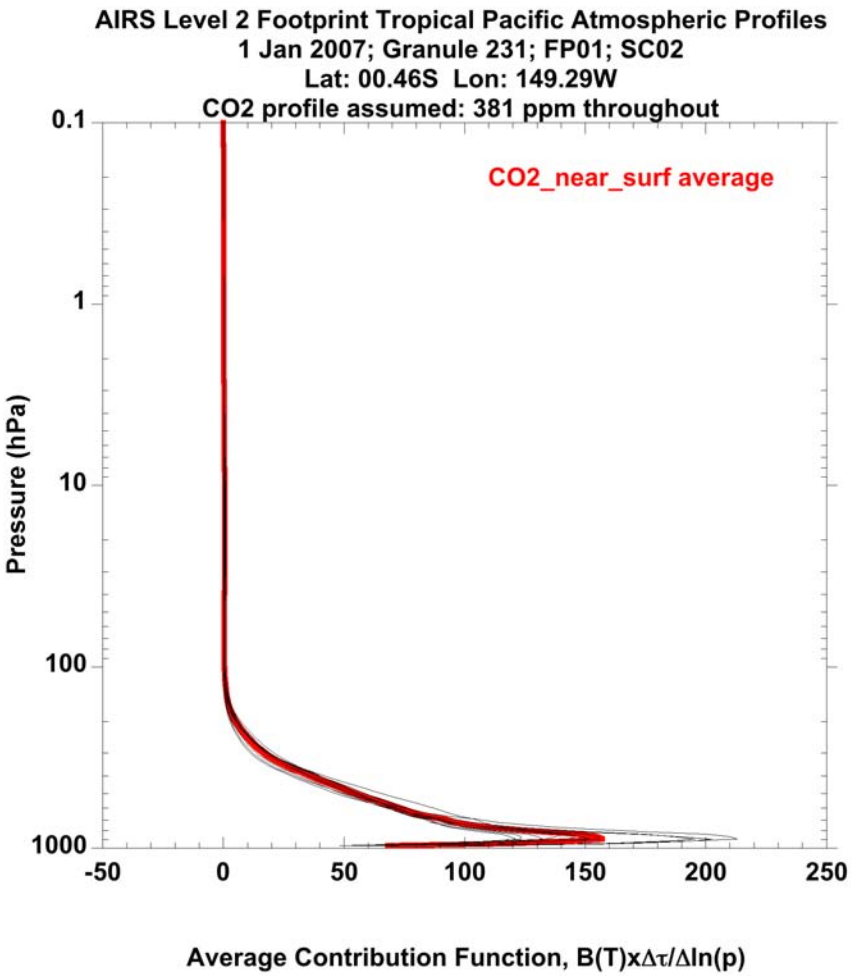


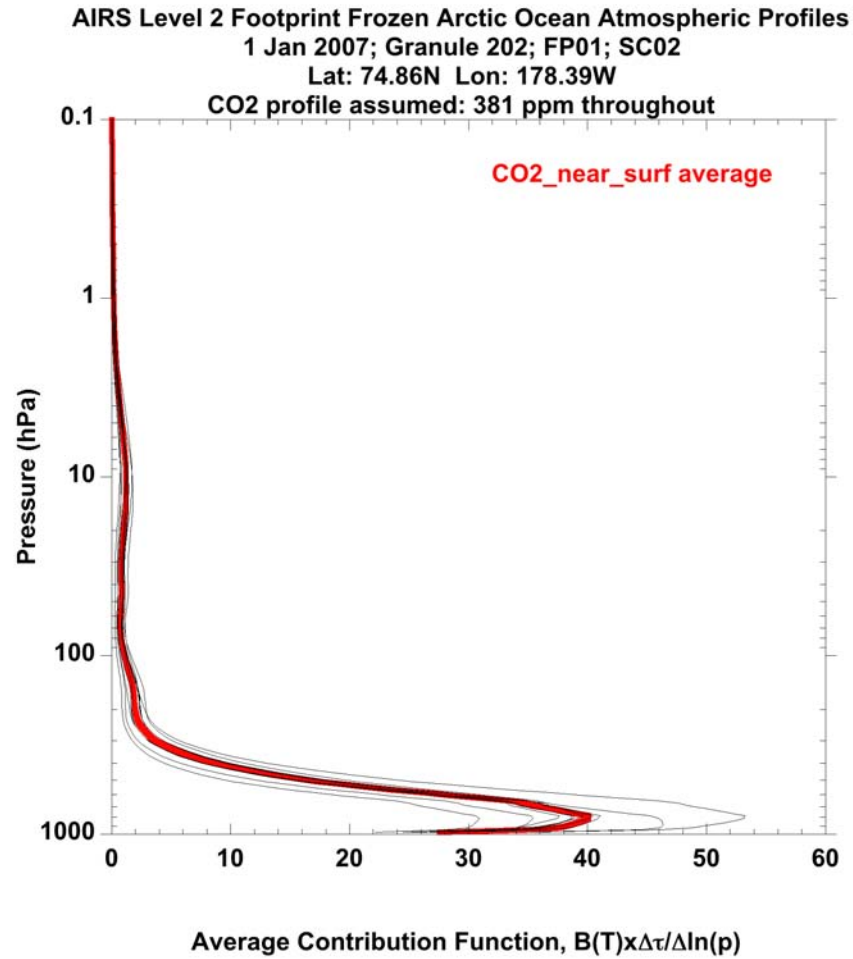
Contribution Functions
Initial Tair Lower-Trop Channel Set using V6 RTA





Contribution Functions
Initial CO2 Near-Surf Channel Set using V6 RTA





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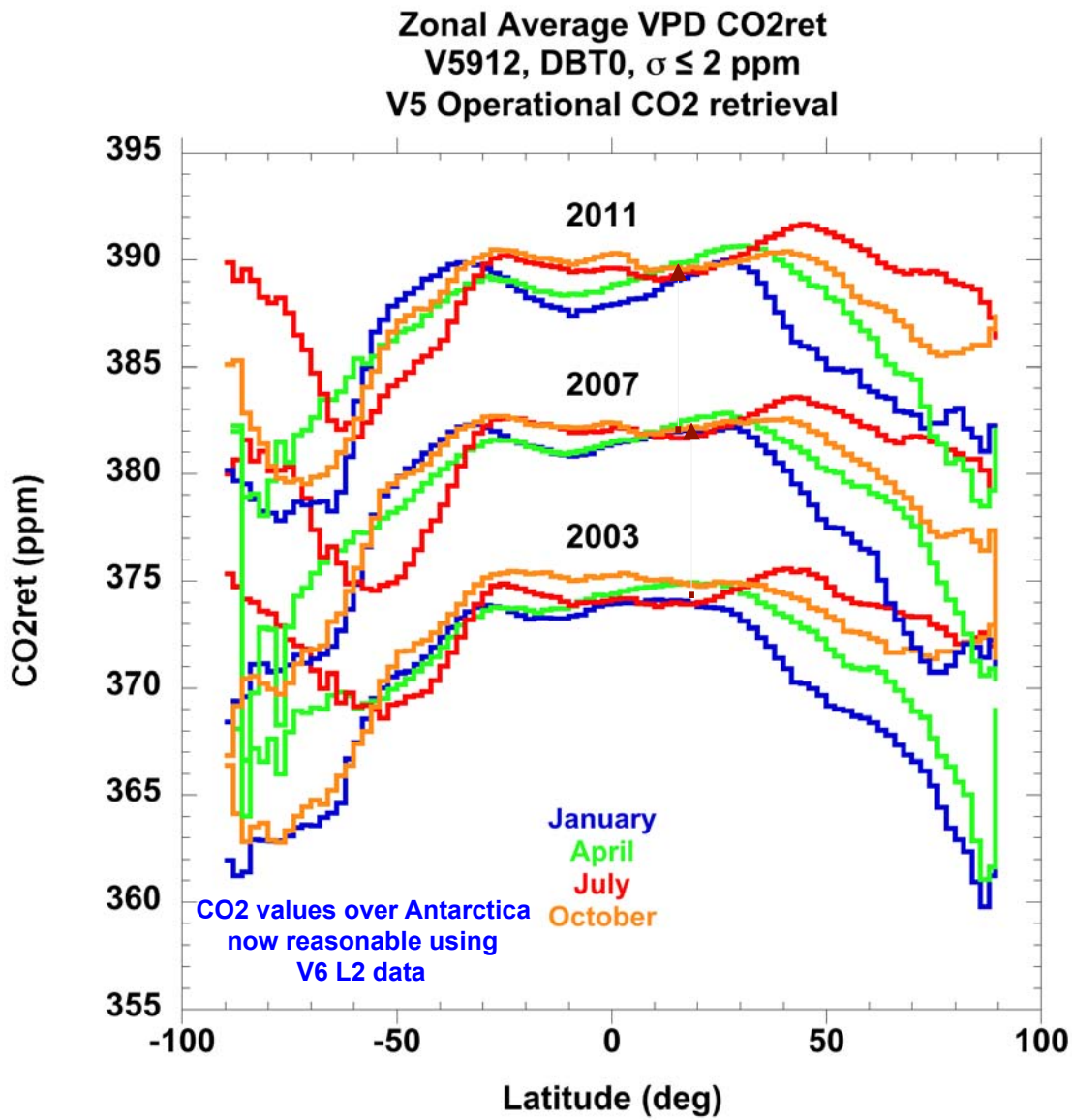
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Atmospheric Infrared Sounder

Interannual and Seasonal Variations Retrieved Mid-Trop CO2 Early V6 L2 Data; Unoptimized V5 Operational VPD

interannual variation is reasonable

expected 8 ppm interannual variation at 2 ppm/yr



high NH latitude variation may be impacted by suboptimal channels (too great a contribution from low stratosphere)

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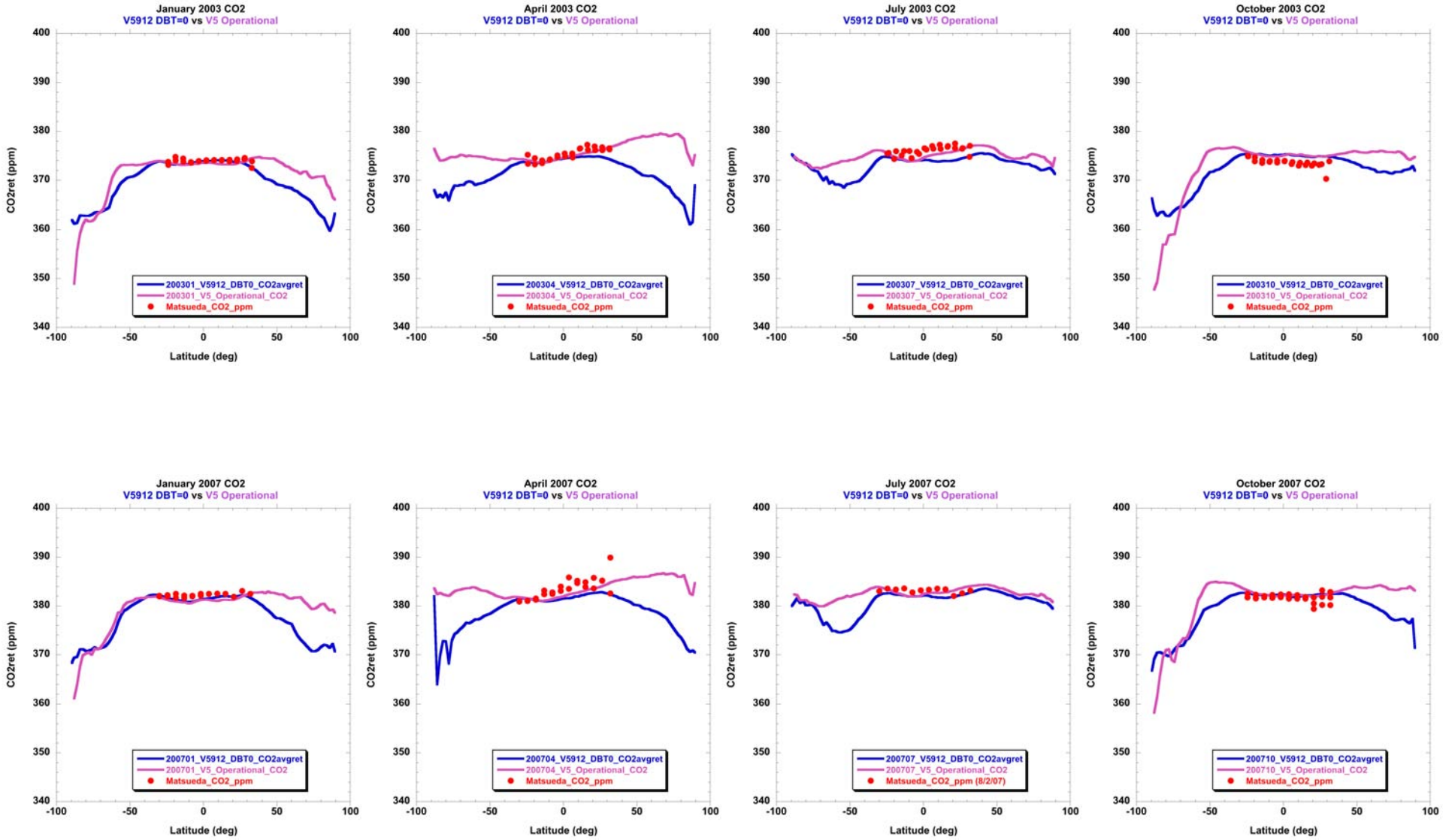
Zonal Average of Retrieved Mid-Trop CO2 Early V6 L2 Data; Unoptimized V5 Operational VPD Compared to Matsueda In Situ Measurements and Zonal Average of V5 Operational Retrieval



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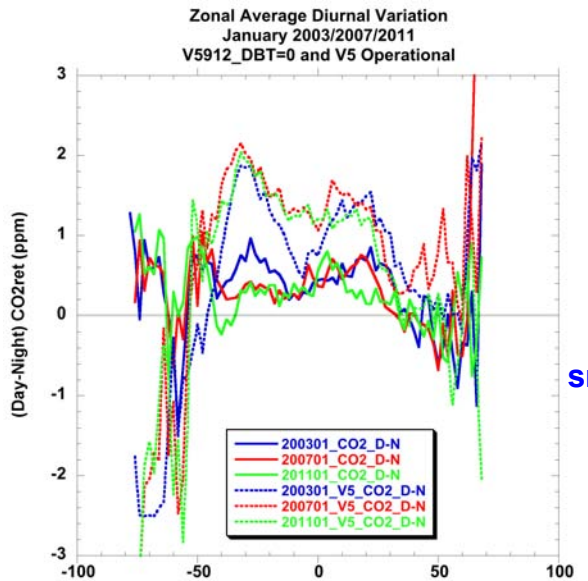
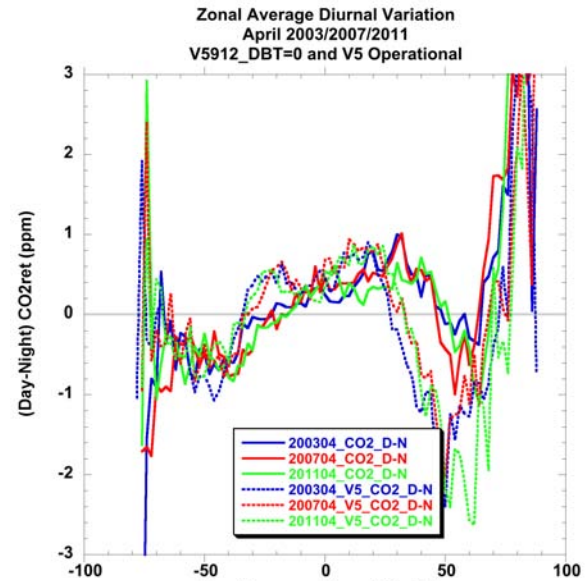
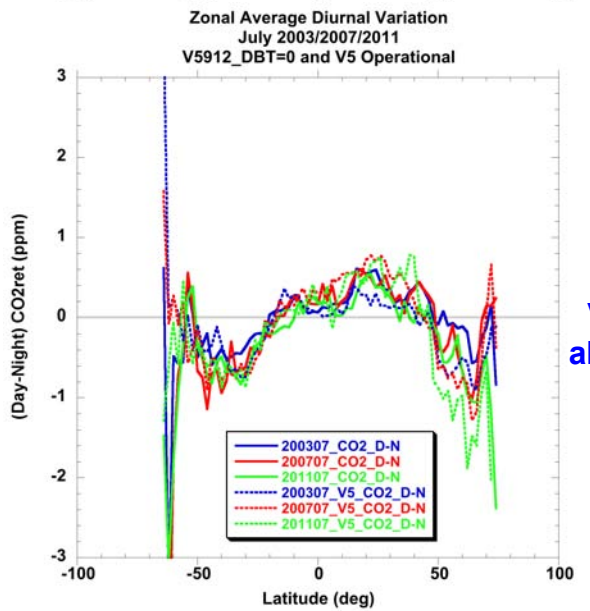
V6/V5 Diurnal Variation Comparison



January
V6 diurnal
about 1 ppm
smaller than V5

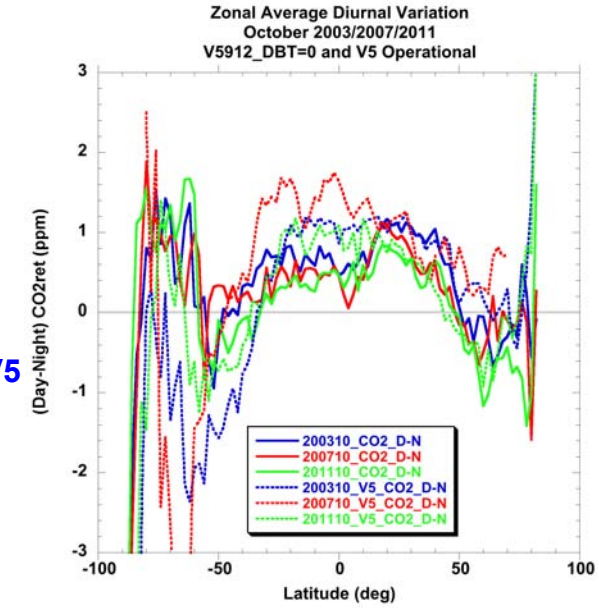
April
V6 diurnal
0.5 - 1 ppm
smaller than V5





July
V5/V6 diurnal
about the same

October
V6 diurnal
0.5 – 1 ppm
smaller than V5



Schedule

Task | Latest Completion Date	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12
V5 channel weight & contribution code transfer (Chen -> Licata)			----------X										
Stand-alone V5 channel weight & contribution tool (Licata/Olsen/Chen)				----------X									
V6 SARTA (Chen -> Licata)	----------X												
V5/V6 channel weight & contribution tool development (Licata/Olsen/Chen)				----------X									
AIRS profile analysis tool (for sensitivity analysis/uncertainty quantification) (Licata/Li/Olsen)							----------X						
V5 mid-strat/mid-trop research s/w restructure and test (Licata/Chen/Olsen)	----------X												
V6 mid-strat/mid-trop research s/w development (Licata/Chen/Olsen)					----------X			----------X					
Analysis module for VPD a's and b's for channels used in retrieval (Chen)							----------X						
V6 mid-trop & mid-strat channel selection (Olsen/Licata/Chen)									----------X				
Compare V6 mid-trop retrievals to in situ measurements, Optimize V6 QA Filters (Olsen)									----------X				
Analyze V6 mid-strat retrievals, Optimize V6 Filters (Olsen)										----------X			
V5/V6 s/w modification (Licata)										----------X			
Deliver V6 mid-trop/mid-strat code to Ops Team												X	
V6 Lower Trop channel selection (Olsen/Li/Licata)											----------X		
V6 Surface Emission Module Development and Test (Chen)									----------X				
Incorporate V6 Surface Emission Module into V6 mid-trop/mid-strat s/w (Licata/Chen)											---------X		
Test V6 Lower Trop retrievals (Olsen/Licata/Chen)									----------X				
V6 mid-strat/mid-trop/lower-trop code ready for Validation against in situ measurements													X

Summary – AIRS V6 CO2 Development

- V6 CO2 retrieval post-processing PGE reorganized for maintainability
  - Legacy research code segments/stubs removed
  - Code modularized and heavily commented
  - Implements both mid-trop and mid-strat capability
    - Choice: channel lists, priors and QA filtering rules; code modules are common
    - Allows easy addition of lower-trop capability
    - Choice of V5 or V6 RTA to allow V5 or V6 data processing
      - Implements V6 Doppler/orbital/seasonal spectral shifts
- Revisiting channel selection – tools developed
  - Analyzing channel sensitivity over globe using V5 and V6 L2 & RTA
  - Identifying sub-optimal channels
  - Optimizing selection criteria and QA filters for V6
- Early V6 results (V5.9.12 ZBT)
  - V5 retrieval PGE for Jan/Apr/Jul/Oct of 2003/2007/2011
    - Interannual variation consistent with global growth of CO2
    - Diurnal variation is small fraction of 1 ppm
    - Lower NH high latitude winter mid-trop CO2 in V6 may be due to sub-optimal channel contribution tails extending into lower stratosphere
    - Reasonable mid-trop CO2 over Antarctica likely due to better temperature profiles over that continent

AIRS V6 CO2 Development

Thank You!