Launch Readiness Issues for AIRS

A status report on some topics in the FINAL Product Retrieval System

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Todays Topics

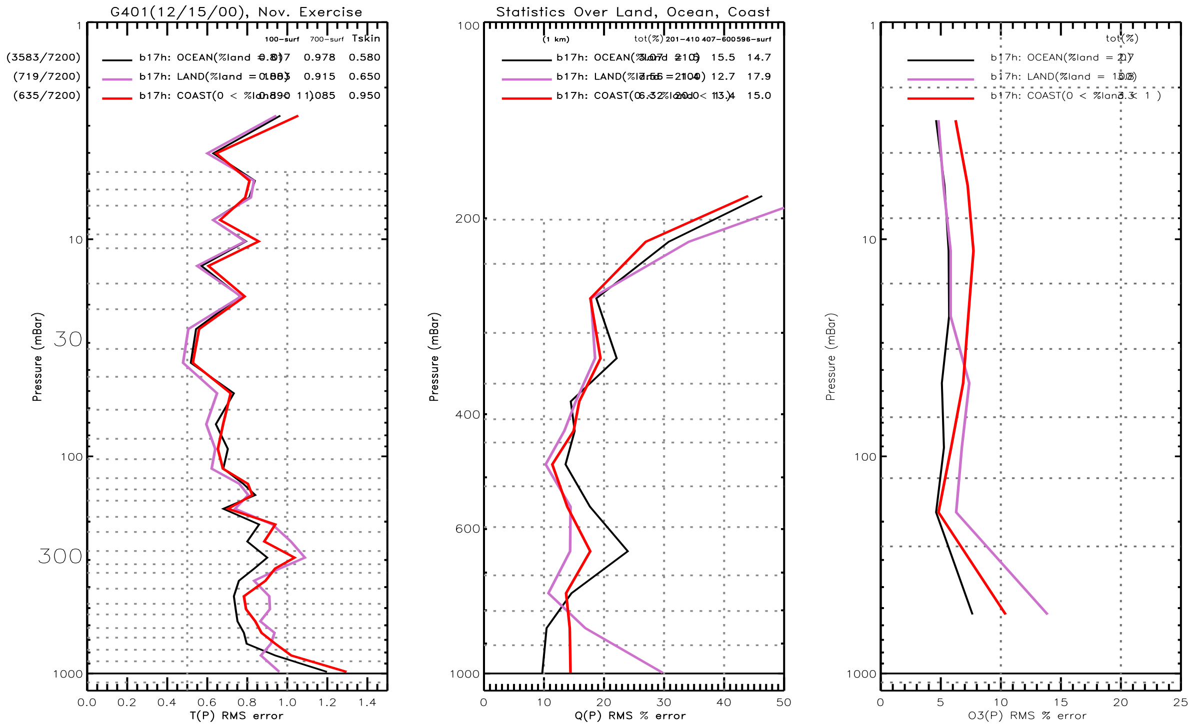
1. The bias in the cloud cleared radiance/surface temperature products.
2. Low yield over Canada and Russia
3. Dependence on NOAA Infrared Emissivity Regression
4. Problems with the Simulation of Upper Tropospheric Water

NOTE:

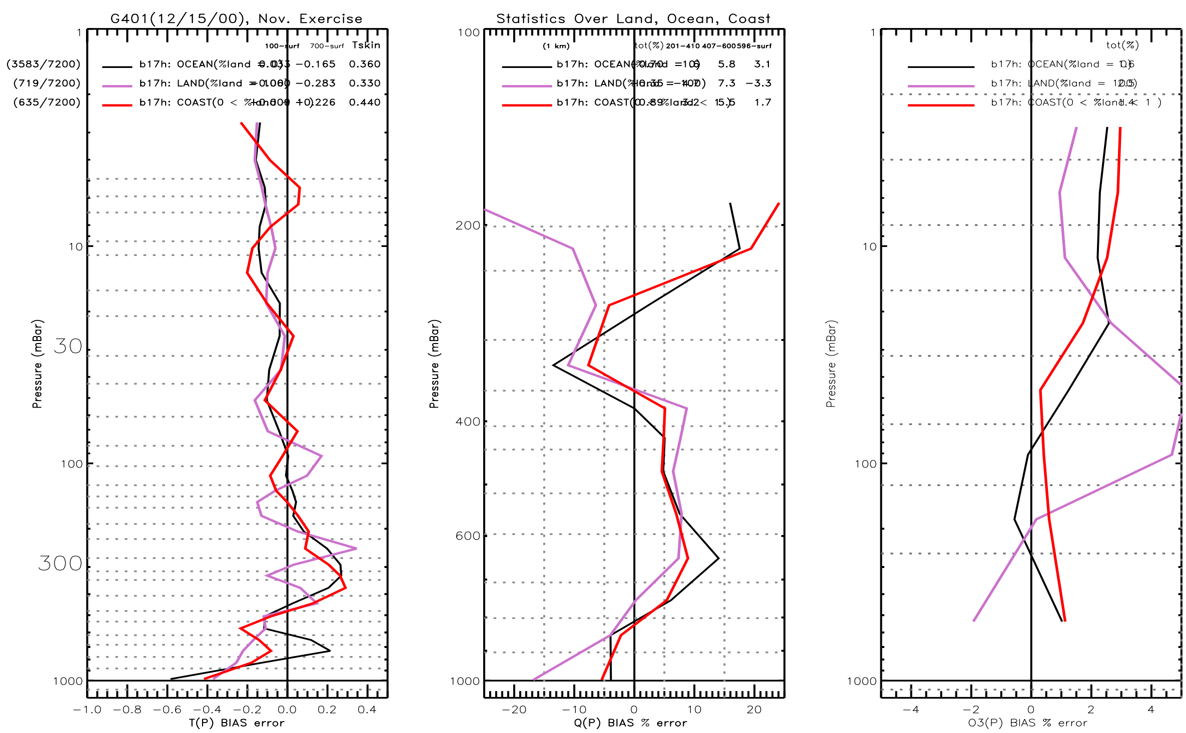
All my experiments are run off-line in a system where I generate my own radiances. The *known* differences between the November exercise and my baseline simulation are:

- There is no local angle correction error.
- The random number sequences used in instrument noise simulation has same statistics as JPL, but is different.

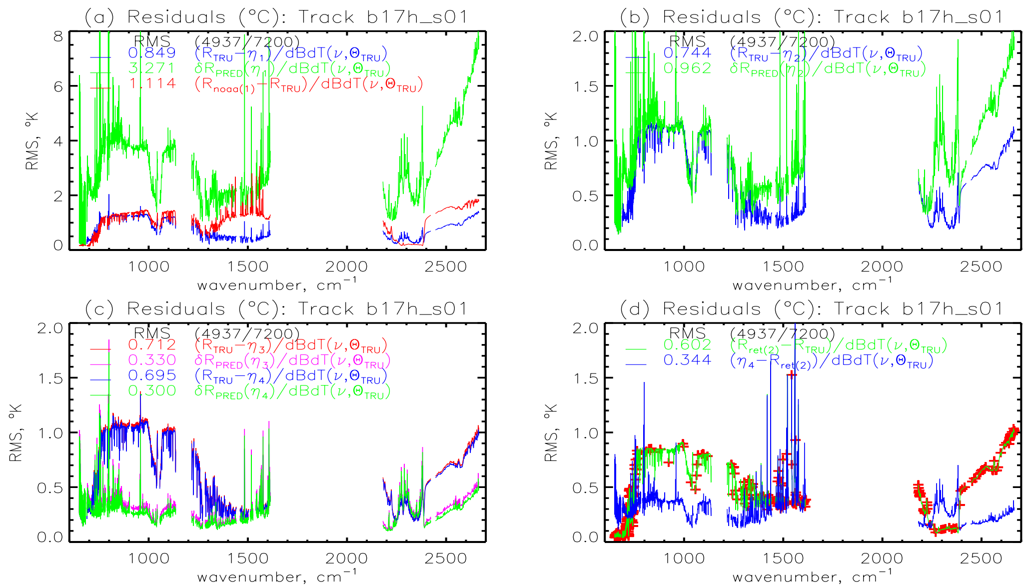
Cold Bias: RMS Error Statistics for Land, Ocean, and 'Coast'



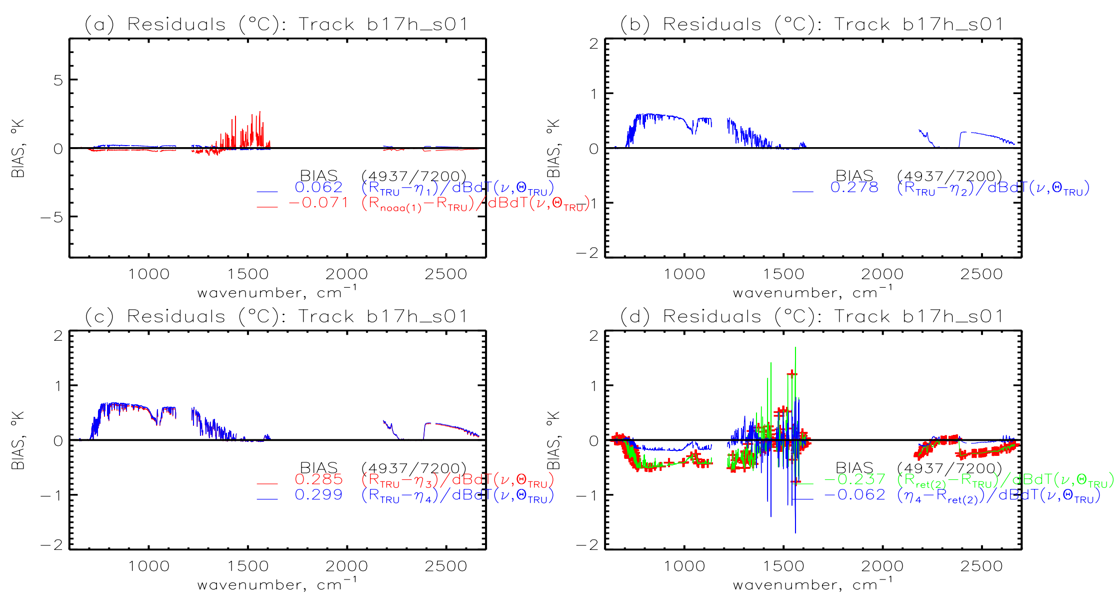
Cold Bias: Mean Error Statistics for Land, Ocean, and 'Coast'



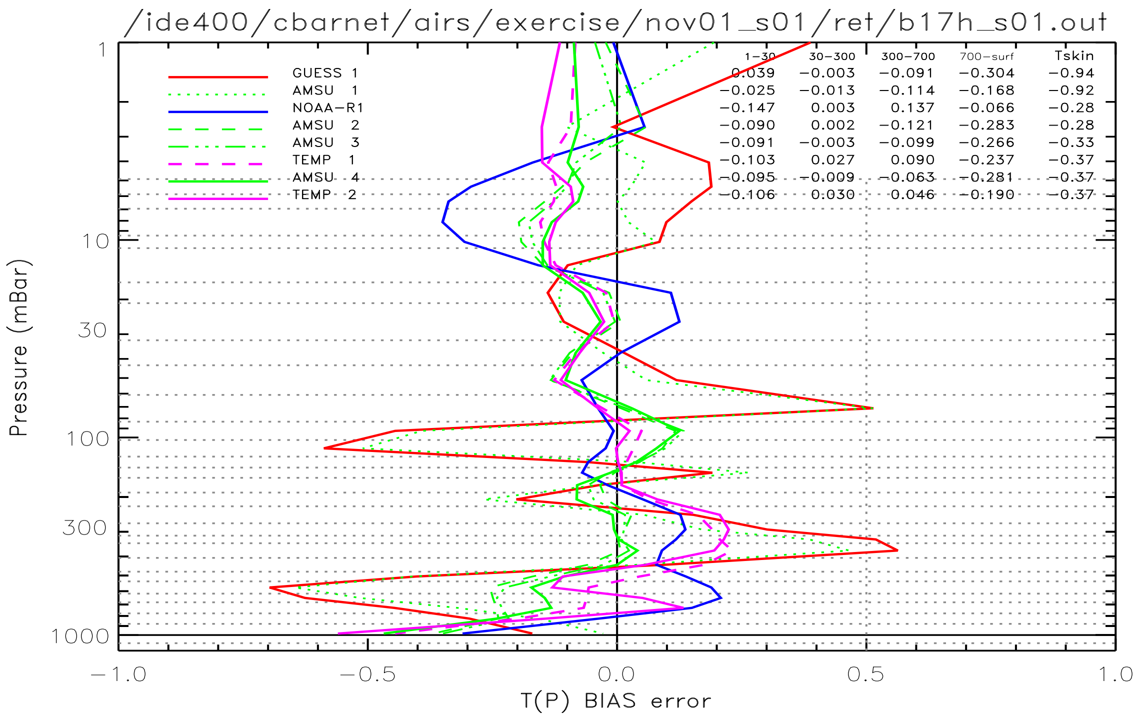
Cold Bias: RMS of Radiance Errors



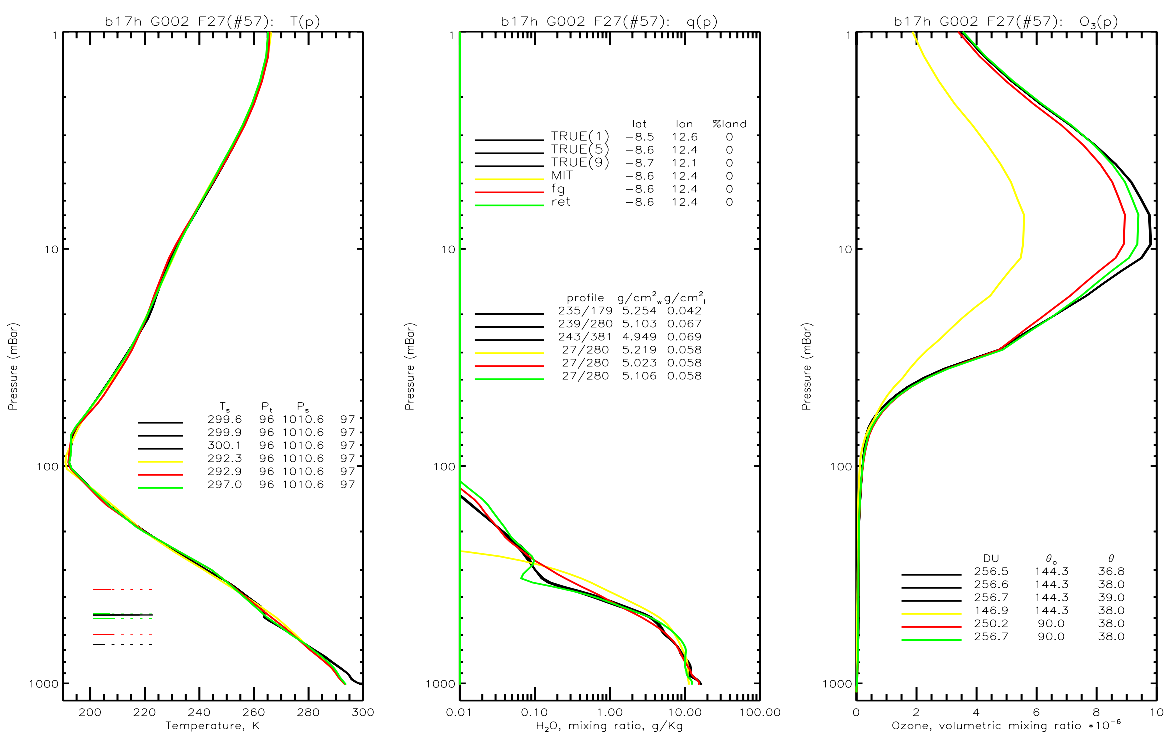
Cold Bias: Mean of Radiance Errors



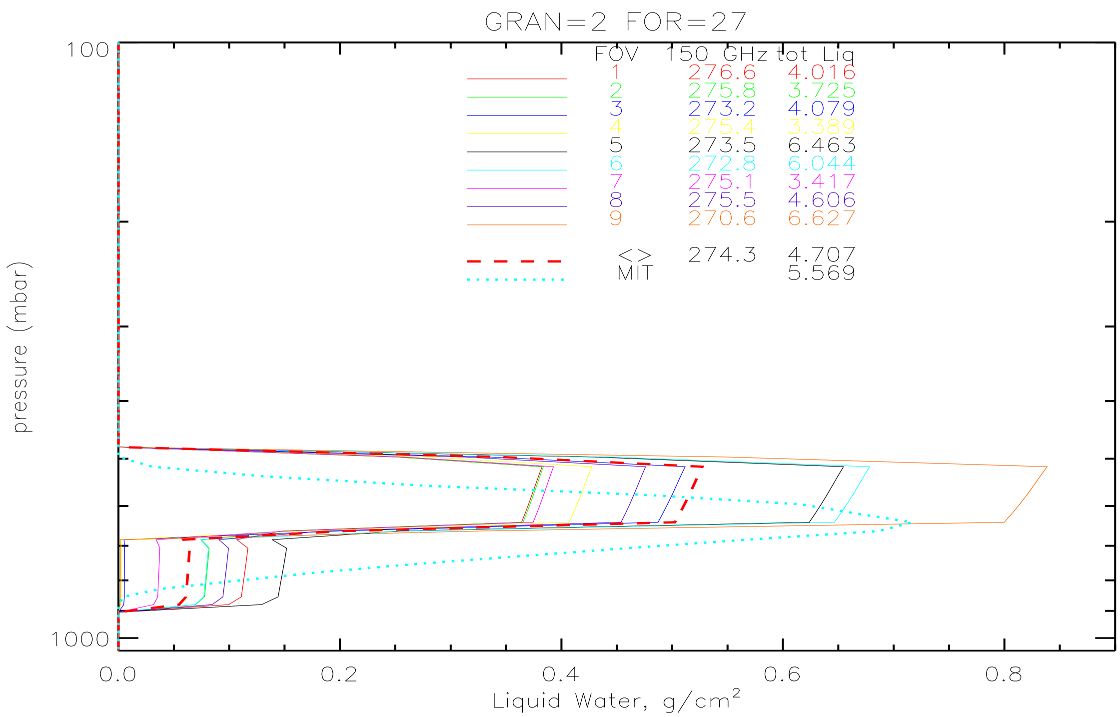
Cold Bias: Problem Emerged Early in the Retrieval System



Cold Bias: Example of a Difficult Profile



Cold Bias: Example of Simulated Liquid Water



Water & Liquid Water Uncertainties

On start-up we use an ensemble error estimate

- Water vapor error estimate, δq, set to 15%
- Liquid water error estimate, δL, = 20% + wcderrfac$\cdot(2 \cdot rh - 1) \cdot q(p)$.
- For G=2, FOV=27 the liquid water error is estimated at 270% due to the large amount of water

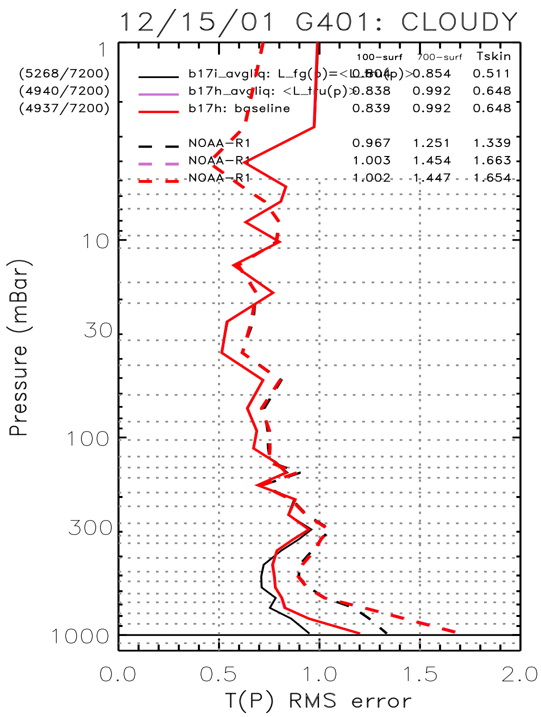
Granule 1, FOV #1: 1.324 cm vapor, 0 mm LIQ					
freq	obs-cal	1/ncv	NEDT	$\delta q \cdot \partial\Theta/\partial q$	$\delta L \cdot \partial\Theta/\partial L$
31.40	-0.2672	3.1445	0.2417	0.2067	0.0000
50.30	-0.2731	3.3607	0.2693	0.1266	0.0000
52.80	-0.1327	5.8071	0.1720	0.0074	0.0000
53.59	0.0523	4.4717	0.2236	-0.0031	0.0000
54.40	-0.0155	5.0701	0.1972	-0.0012	0.0000
54.94	-0.0020	5.8124	0.1720	-0.0003	0.0000
89.00	-0.3938	1.3816	0.1562	0.7068	0.0000
Granule 2, FOV #57: 5.102 cm vapor, 0.490 mm LIQ					
31.40	2.5019	0.0284	0.2417	4.0356	35.0345
50.30	1.6096	0.0821	0.2693	1.5580	12.0775
52.80	0.6520	1.8627	0.1720	0.1243	0.4931
53.59	-0.0095	2.0840	0.2236	-0.0243	-0.4239
54.40	0.0906	4.3027	0.1972	-0.0099	-0.1225
54.94	0.0290	5.7615	0.1720	-0.0021	-0.0228
89.00	1.1084	0.3076	0.1562	1.2644	2.9906

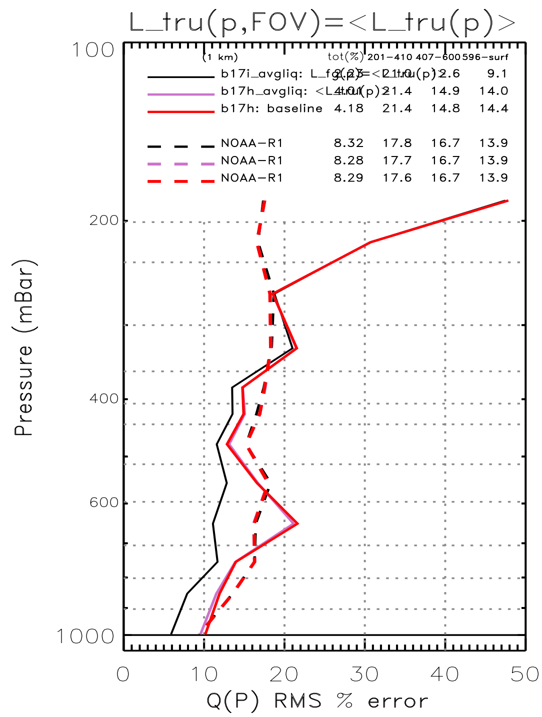
Cold Bias: Summary of Recent Experiments

- The most severe problems occur immediately and the problem is amplified by the cloud clearing and physical surface retrieval.
- It is illustrative to note that many diagnostic experiments did not help, for example
  - set SST = TRUTH had no effect
  - set $\epsilon_{IR}(\nu)$ = center spot of TRUTH had no effect
  - optimization of retrieval parameters did not significantly alter the solution (functions, using 31.4, 89 GHz, damping parameters)
- Analysis of detailed printout of the worst cases showed that the retrieval failed because AMSU obs-calc's were minimized about a cold biased state in the lower troposphere.
- I build a truth set in which all 9 FOV's liquid water was set equal to the average value (dashed red line in previous figure).

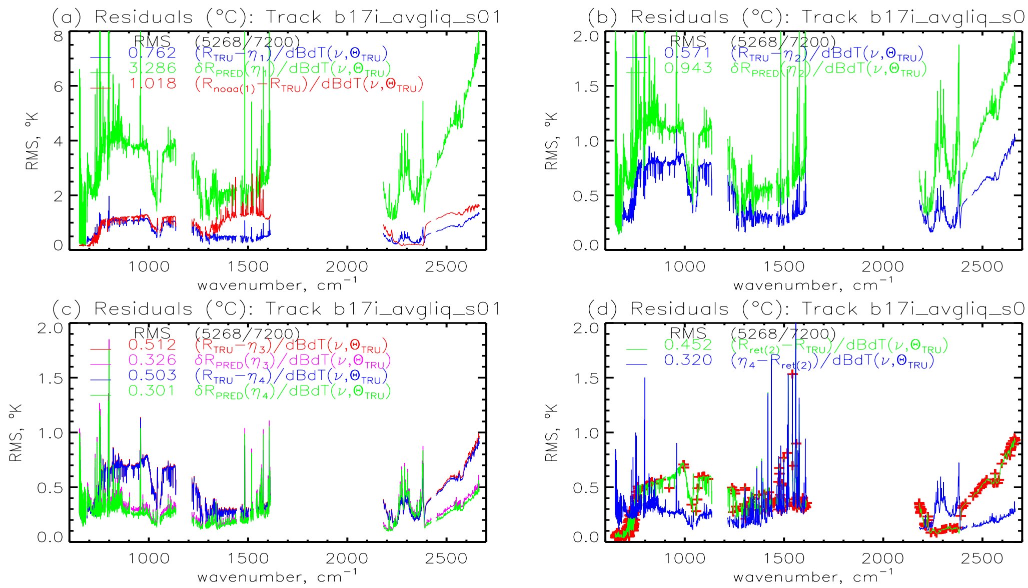
					Gran=2, FOR=27			
					AMSU #1 step		FINAL T(p) step	
	simulation	LIQ(p)		89 &	error in	error in	error in	error in
experiment	L2.truth	fg	wcderrfac	150 GHz	875-surf	T_{surf}	875-surf	T_{surf}
b17h:	LIQ(9)	MIT	0.05		-4.50	-7.31	-2.85	-4.04
b17h_avgliq	<LIQ>	MIT	0.05		-4.45	-7.27	-2.80	-3.98
b17i_avgliq	<LIQ>	<TRUTH>	0.05		-3.74	-7.00	-1.43	-2.33
b17j_avgliq	<LIQ>	<TRUTH>	0.001		-3.05	-6.24	-1.39	-2.06
b17k_avgliq	LIQ(9)	<TRUTH>	0.001		-3.77	-7.03	-1.46	-2.40
b17o1_avgliq	<LIQ>	<TRUTH>	ON		-3.74	-7.00	-1.43	-2.33
b17o2_avgliq	<LIQ>	<TRUTH>	off		-2.98	-6.03	-1.33	-1.96
b17o3_avgliq	<LIQ>	<TRUTH>	ON	yes	-3.83	-7.21	-1.29	-2.05
b17o4_avgliq	<LIQ>	<TRUTH>	off	yes	-3.10	-5.64	-1.18	-1.64

Cold Bias: Liquid Water Experiments, RMS

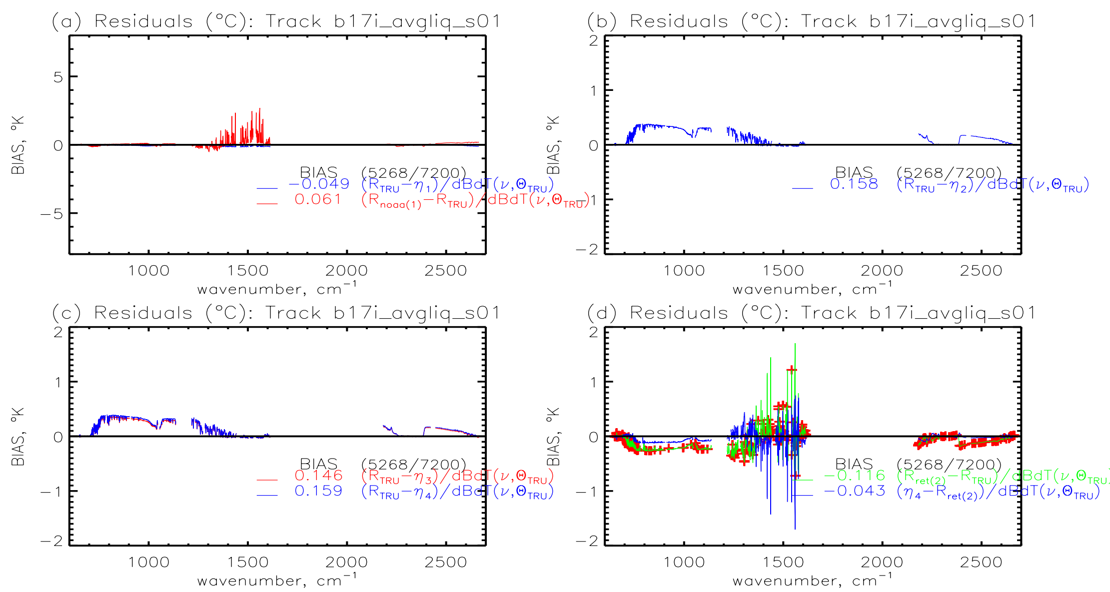




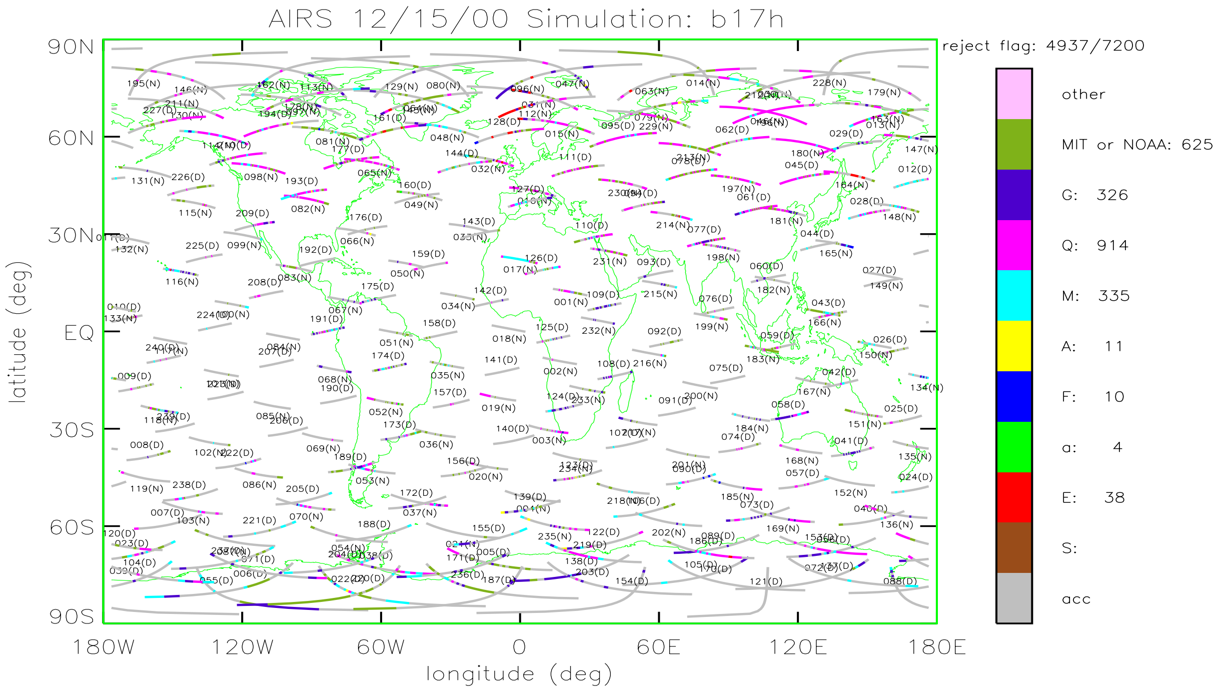
Cold Bias: RMS of Radiance Errors



Cold Bias: Mean of Radiance Errors



Low Yield: Where do we reject?



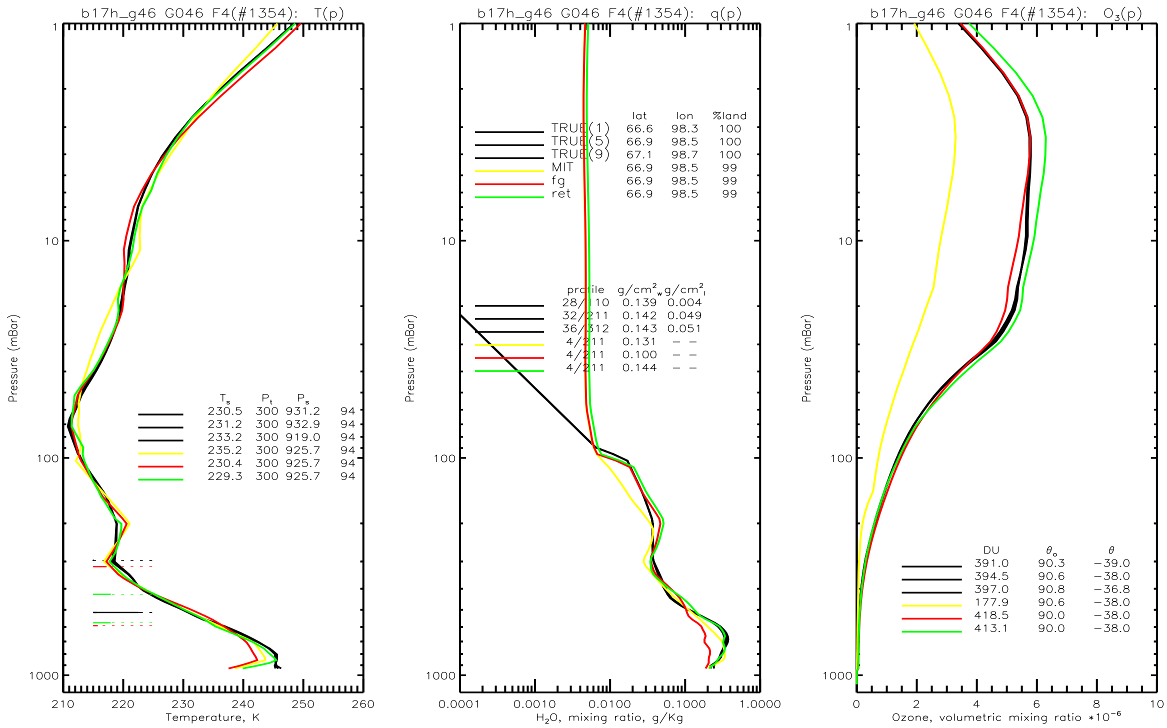
Low Yield: Granule 46: Why do we reject?

Granule 46 we accept 2 cases: Here are some details on some of the others:

IDX	typ	Ampl	erj2	cld	cl5	IR-x	R(b)	surf	temp	Ts	cld	cl5	T(bt2)	
1351	1-C	.338	.330	.052	.040	.213	.225	1.57	.468	-.53	.026	.016	.797	
1352	3+C	.423	.446	.172	.148	.232	.568	2.91	.365	-2.5	.069	.061	.588	
1353	2-C	.506	1.15	.207	.104	.222	.574	2.83	.379	-1.0	.244	zero	1.14	
1354	1-C	.617	1.30	.585	.292	.384	.408	2.59	.402	-2.1	.616	.616	2.35	<==
1355	3+C	.766	1.01	.486	.249	.352	.128	2.21	.231	-1.9	.522	.522	1.80	
1357	3+C	.849	1.11	.628	.363	.388	1.53	3.00	.367	-2.3	.603	.602	.240	
1359	3+C	.732	1.29	.399	.197	.365	1.32	2.60	.481	-2.0	.435	.429	.387	
1363	3+C	.468	0.97	.034	.006	.188	.156	2.40	.377	2.23	.158	.156	2.56	
1365	3+C	.570	.475	.118	.079	.277	.233	2.90	.322	1.54	.232	.232	1.58	
1366	2-C	.424	1.08	.096	.059	.322	.190	3.63	.536	1.52	.199	.199	2.44	
1367	3+C	.580	.737	.065	.032	.245	.488	2.76	.576	1.19	.173	.173	.920	
1370	1-C	.429	.688	.096	.084	.203	.280	2.76	.526	-1.3	.116	.109	1.37	
1374	3+C	.796	.855	.180	.095	.280	1.14	3.09	.214	-1.9	.153	.053	.949	
1375	3+C	.897	0.96	.114	.079	.295	.397	1.79	.330	-1.4	.138	.040	.668	

⇒ Most of the cases are being rejected due to poor residuals in the surface retrieval.

Low Yield: Granule 46, FOV #4 (index = 1354)



NOTES: (1) Cold, (2) Large Quantity of Liquid Water, (2) UTH difference (for later)

Low Yield: Why are we rejecting

First of all, many things are quite good with this (these?) retrieval(s)

- zero liquid water
- microwave emissivity is quite good ($\epsilon_{fg} = 0.749, \epsilon_{tru} = 0.764$),
- microwave T(p) has -7° K error at the surface, but T_{skin} compensates with a +4° K error.

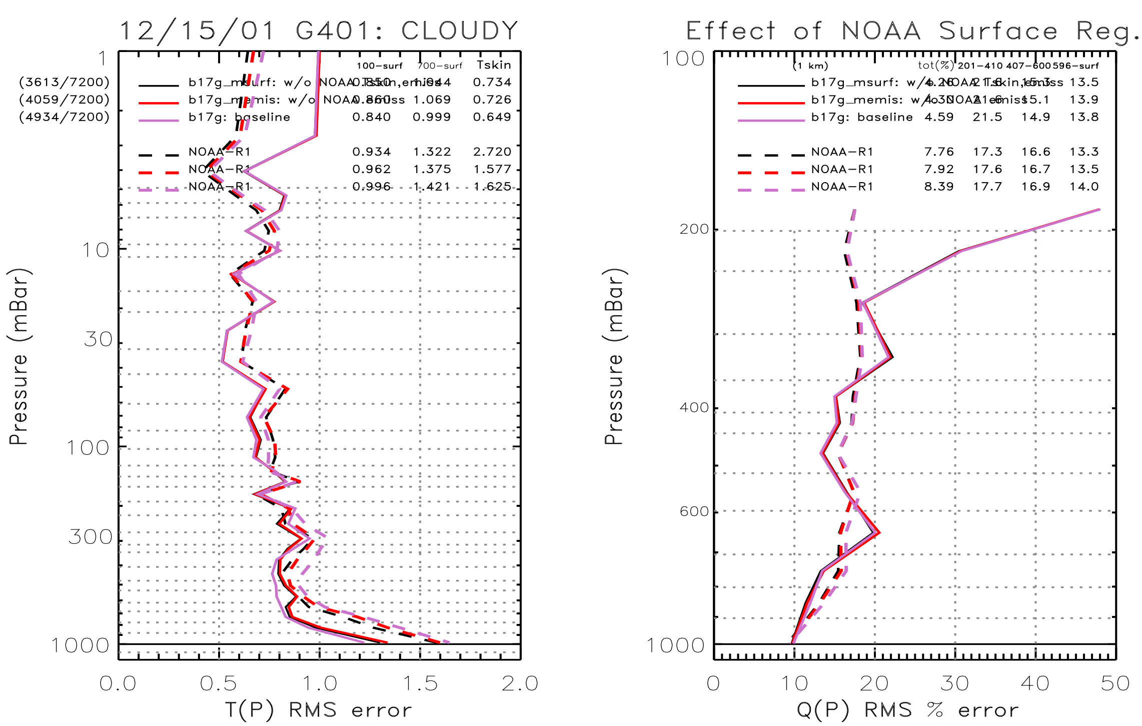
But the case is difficult because

- 62% cloudy
- -40° C
- % land = 99.66
- I think these are indicative of the trade-off between meeting the 1° per 1-km goal with a single day of data and having a reasonable rejection criteria for difficult cases.
- We may have sub-optimal error estimate propagation in the surface retrieval, thereby an underestimate of error for cold cases increases the number of rejected cases.

NOAA Regression

- The issue is this: if synthetic regression DOES NOT work, then our retrieval system must run without an emissivity regression since a training emissivity product does not exist to sufficient accuracy.
- I ran 2 experiments to determine our sensitivity and referenced them to a baseline run
  - b17g: baseline run
  - b17g_msurf = b17g without regression solution for T_{surf} or $\epsilon_{IR}(\nu)$
  - b17g_memis = b17g without regression solution for $\epsilon_{IR}(\nu)$
- Results do not seem to degrade significantly; however, the yield drops substantially.

NOAA Regression



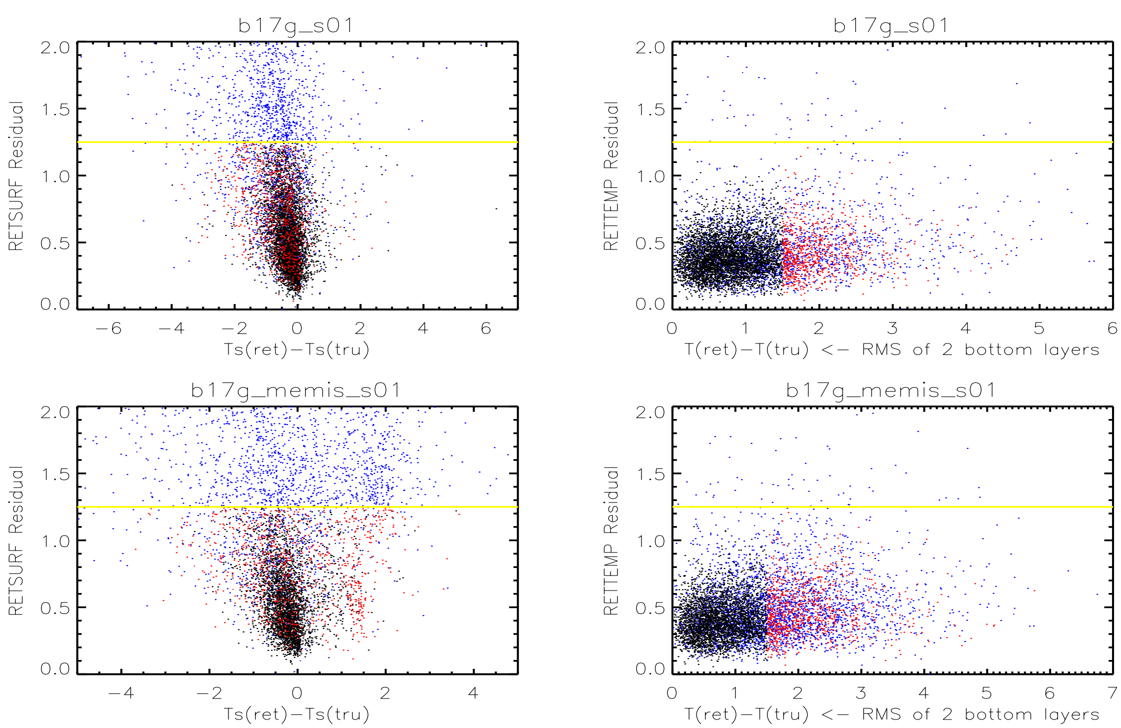
NOAA Regression: Rejection Summary

# cases rejected due to:			
	baseline	w/o ϵ regression	w/o ϵ & T_{skin} regression
$A_{eff} > 8$	577	1030	1132
Quality > 1.25	1256	2520	2719
IR vs. MW	382	713	700
cloud frac. > 90%	7	18	15
CCR residual	38	127	1044

# cases accepted:			
	baseline	w/o ϵ regression	w/o ϵ & T_{skin} regression
# ocean accepted	3564	3259	2852
# land accepted	725	351	346
# coast accepted	645	449	415
# total accepted	4934	4059	3613

- Yield drops by 50% over land without emissivity regression.
- Yield drops $\approx$ 10% over ocean for both Emissivity and T_{surf} regression.

NOAA Regression: Surface & T(p) Rejection Ability



Upper Tropospheric Humidity (UTH) Issue

- In the Figure on slide #16 (G46, FOV #4) you can notice the water profiles in the truth diminish above the tropopause.
- This only affects cases with extremely low water (mostly polar).
- Radiance residuals for opaque channels in 6.6 μm region were large due to failure of retrieval in the upper troposphere.
- SAGE-II data (provided by Shawn Turner, AES) typically has a nearly constant mass mixing ratio (0.002-0.003 g/kg of water above 100 mB), therefore, problem is in the simulation.
- Designed an experiment to determine what our UTH statistics would look like for a more realistic simulation.
  - q(0.005 mb) = 0.002 + r*0.001 g/kg
  - q(100 mb) = q(0.005 mb) + r*0.0005 g/kg, pressure interpolated in between

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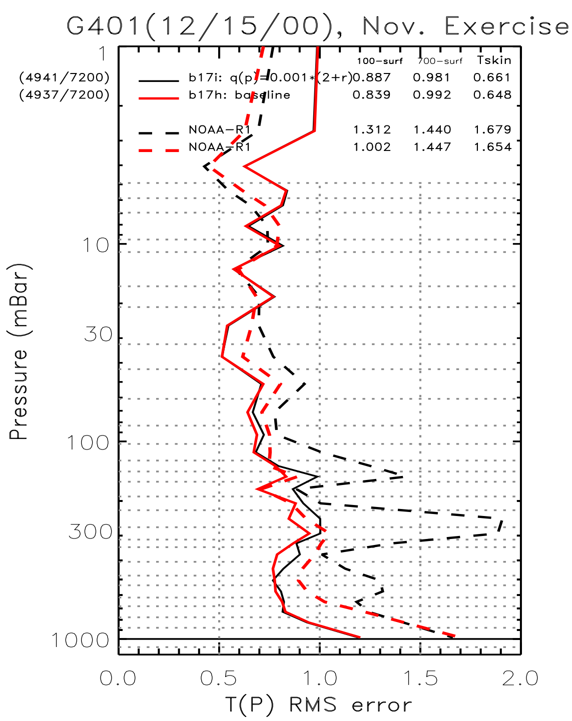
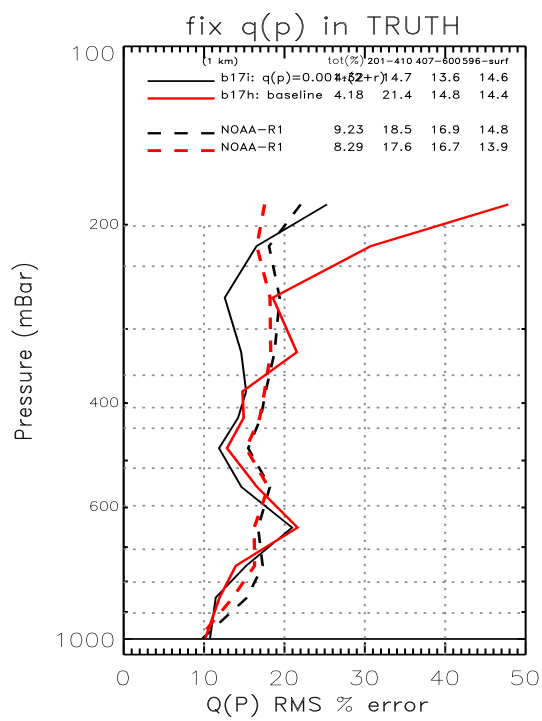
UTH: Experiment Results

- Regression has some training issues.
- Statistics improve in the stratosphere due to the more realistic (and larger) truth. That is truth no-longer tends towards 0, therefore, (ret-truth)/truth is a smaller value
- The retrievals improve in the upper troposphere due to the more reasonable radiances (*i.e.*, the first guess water is now reasonable in the stratophere)

UTH: Statistics for G401





- Woops, hey Mitch, what's this ⇑

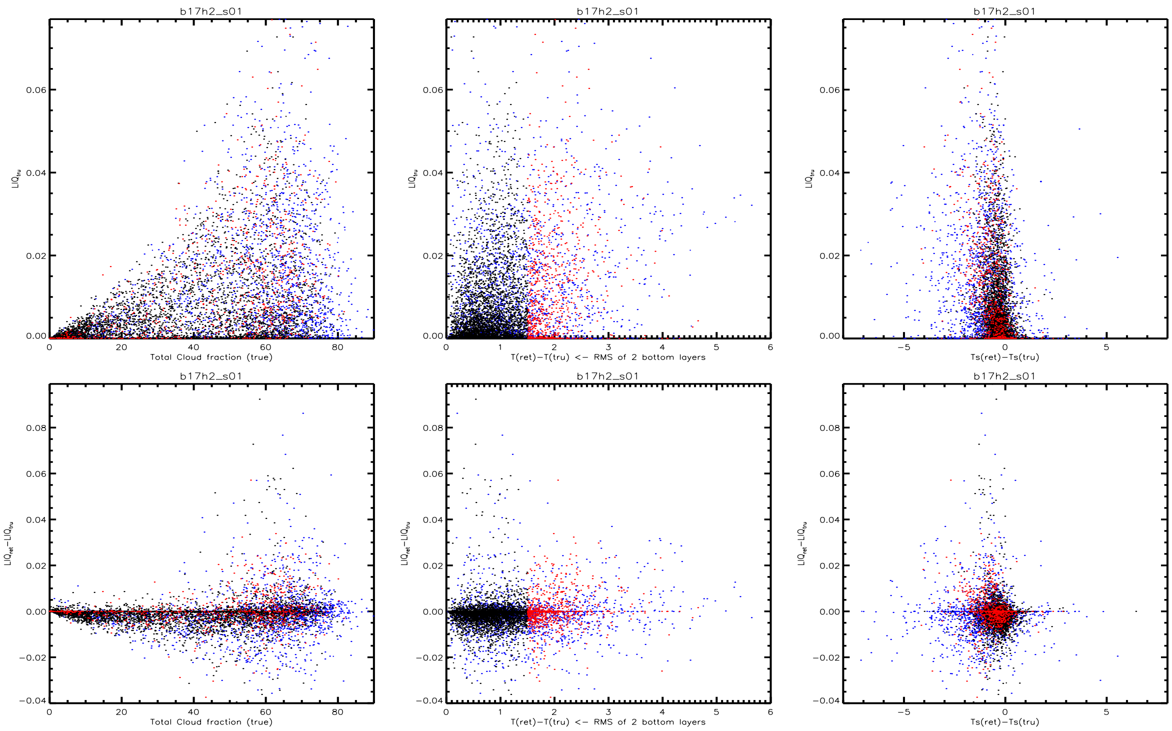
Summary and Final Thoughts

- COLD BIAS
  - add FINAL product for liquid water
  - improve error covariance estimates for liquid water
  - add FINAL product for spectral microwave emissivit
  - Replace the initial microwave steps in Initial Cloud Clearing with a simulataneous water and temperature retrieval step using HSB & AMSU.
  - add or modify rejection criteria for cases with large amounts of water and liquid water.
  - optimize retrieval parameters in early AMSU steps (specifically, channels, functions, and estimates for undertainty)
- Low yield issue seems to be a trade-off between yield and precision.
- The NOAA REGRESSION issues can probably be resolved with some analysis of the physical surface retrieval with CLOUDY radiances. Items above will most likely help some cases.
- Physical retrieval of UTH should be optimized.
- NOAA regression needs reasonable UTH for training.

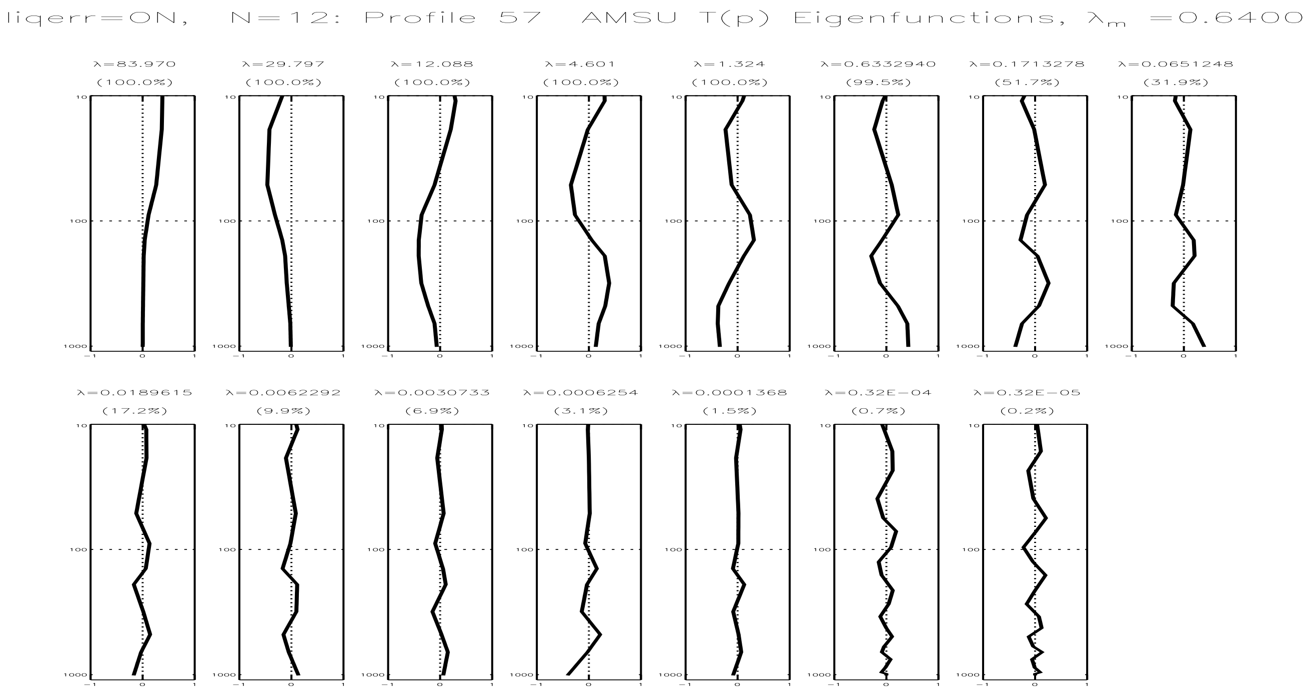
BUT

- It is time for me to turn my attention to being prepared for post-launch analysis.
- The off-line diagnostic capability is a necessary component of being launch ready.
  - quick simulation analysis relative to a reasonable truth (*e.g.*, ECMWF, co-located radiosondes truth, etc.)
  - all code operates without "truth" and provides useful information at all steps within the retrieval. (*e.g.*, obs-calc, $\Delta T(p)$ in each step)
- The following work needs to be done **now** with the off-line diagnostics system:
  - add MIT retrieval code
  - add Larry's angle correction code
  - develop L1b interface (HDF file, L1b quality indicators)
  - develop first guess interface
    - plumbing issues with P_{surf}, etc.
    - NCEP, ECMWF experiments?
  - Robustness issues

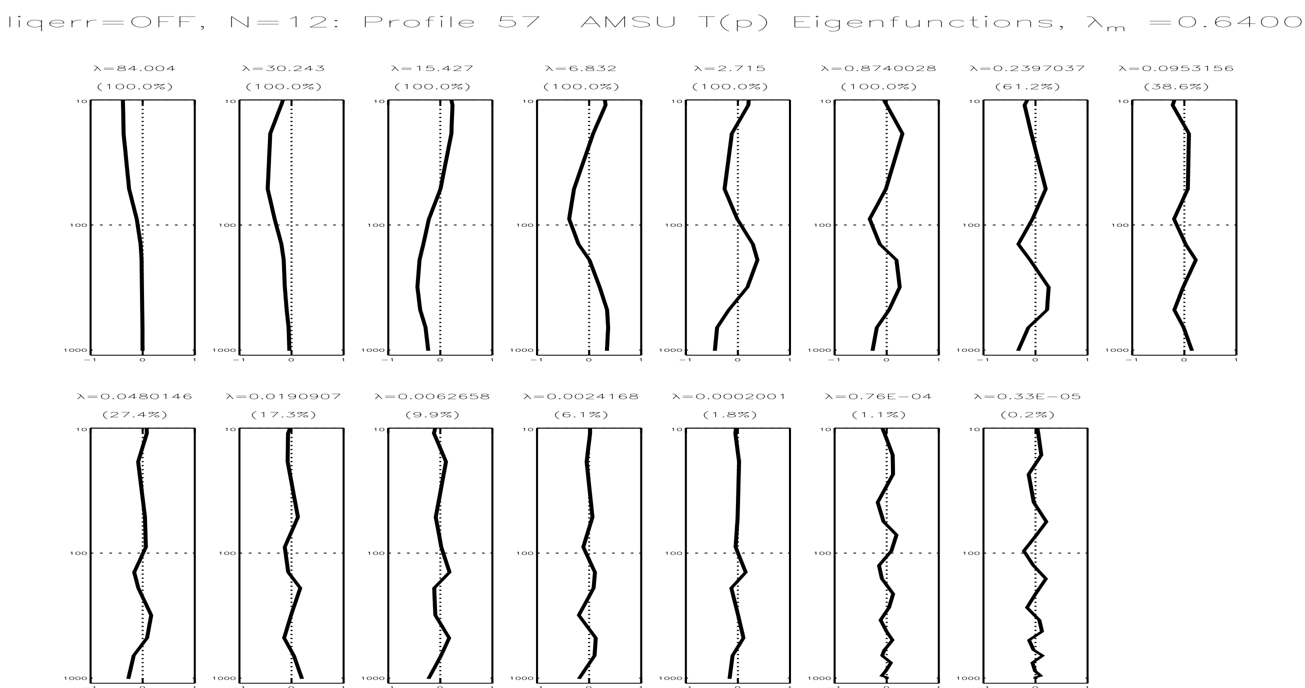
Cold Bias: Backup Slide



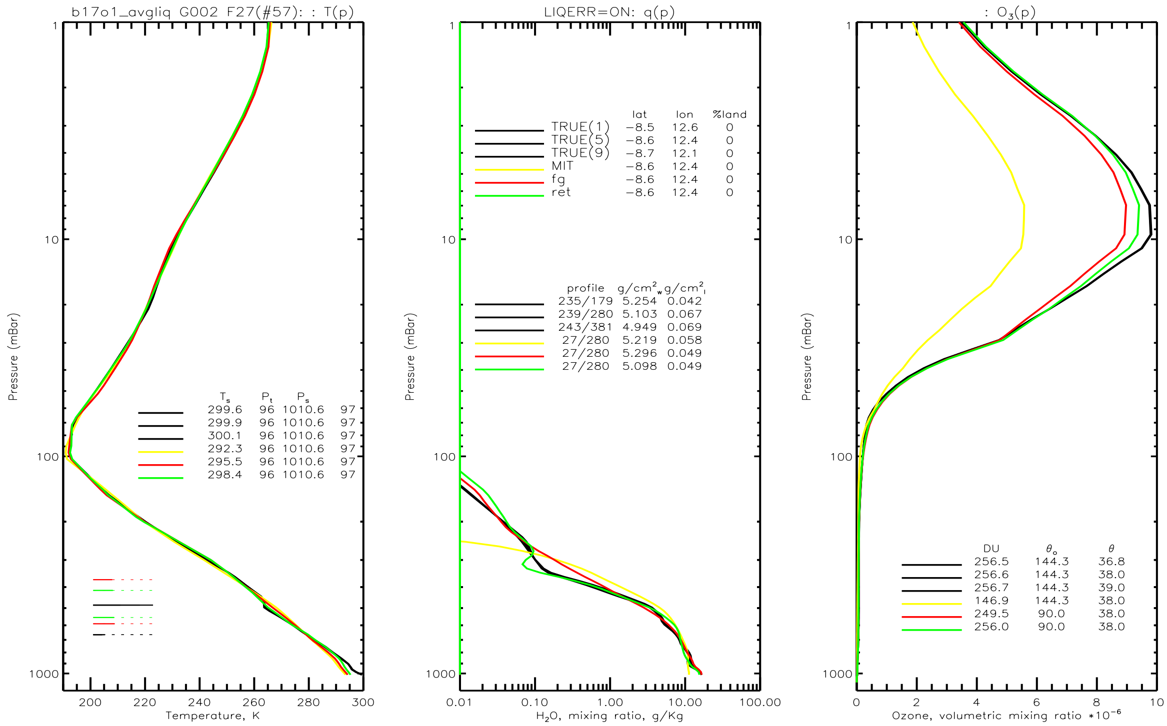
Cold Bias: AMSU Eigenfunctions (LIQERR=ON)



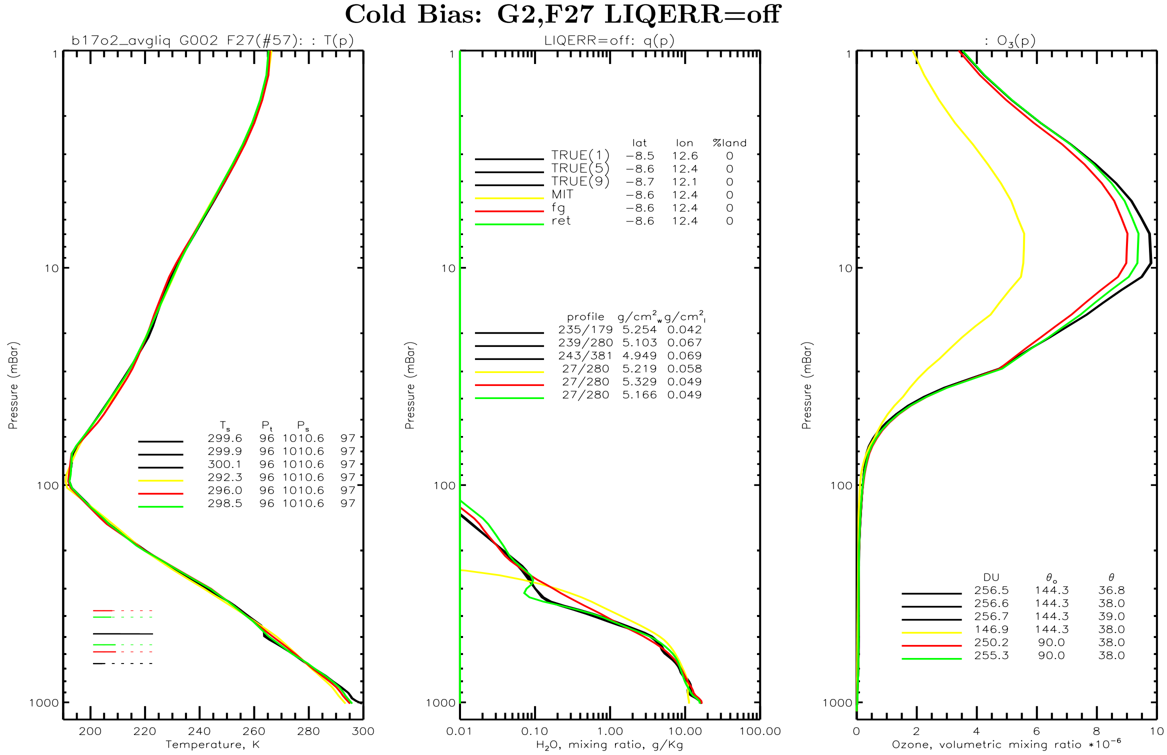
Cold Bias: AMSU Eigenfunctions (LIQERR=off)



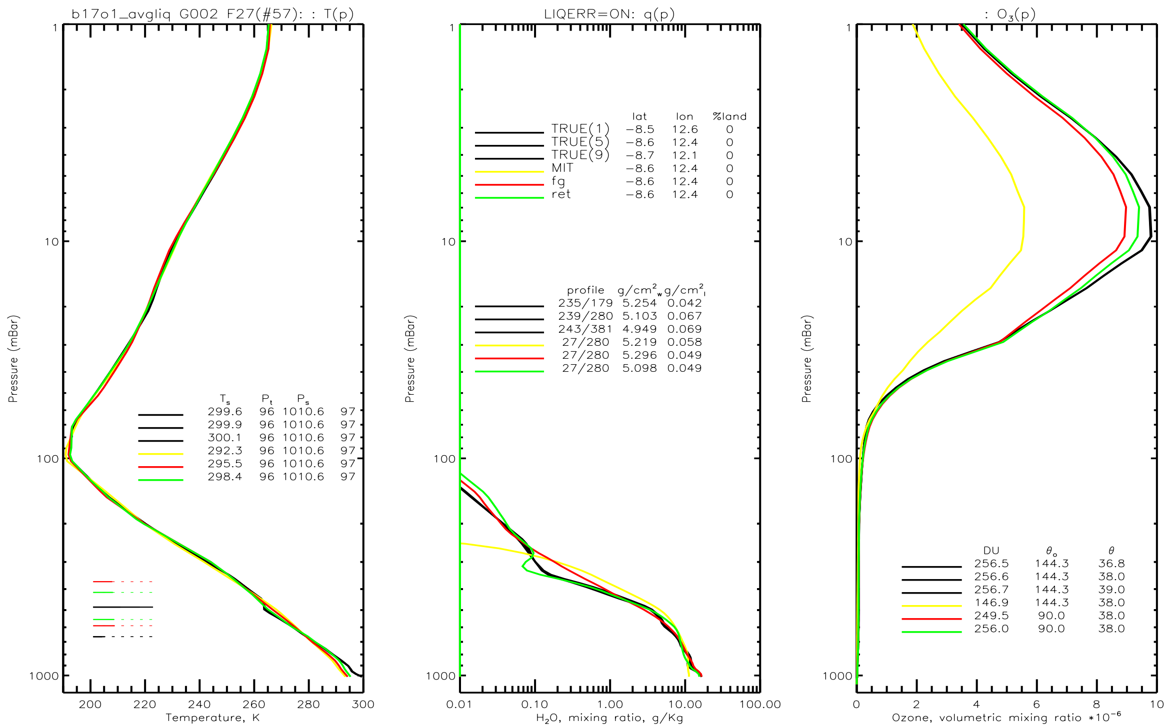
Cold Bias: G2,F27 LIQERR=ON



Cold Bias: G2,F27 LIQERR=off



Cold Bias: G2,F27 LIQERR=ON, +89, 150 GHz



Cold Bias: G2,F27 LIQERR=OFF, +89, 150 GHz