Identification of AIRS clear fields, first retrieval performance

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BACKGROUND

- NESDIS will be distributing AIRS radiances to NWP centers in near real-time.
- NWP centers will assimilate clear radiances
- Need very good cloud detection algorithm
- Very important for radiance validation and to initiate the testing of the level 2 retrieval code.

Objectives

- Provide information indicating if fov is clear with a confidence indicator.

- If not clear:
  - provide cloud amount and height.
  - indicate channels not affected by clouds

Clear Detection – Combination of 3 tests

- AMSU channels 4, 5 and 6 are used to predict AIRS channel at 2390.9 cm-1.

*Predicted AIRS at 2390.9 = 11.327-.185*amsu4+1.930*amsu5-*
*0.777*amsu6+1.048*csza-4.243*(1.-cang)*

where csza = cosine solar zenith angle

cang = cosine view angle (scan angle)

amsu4 = amsu channel 4 brightness temperature , etc

- FOV is labeled "mostly clear" if predicted AIRS – observed AIRS < 2

  AND IF

- SW LW IR window test is successful:

  [ch(2558.224)-CH(900.562)] < 10 K

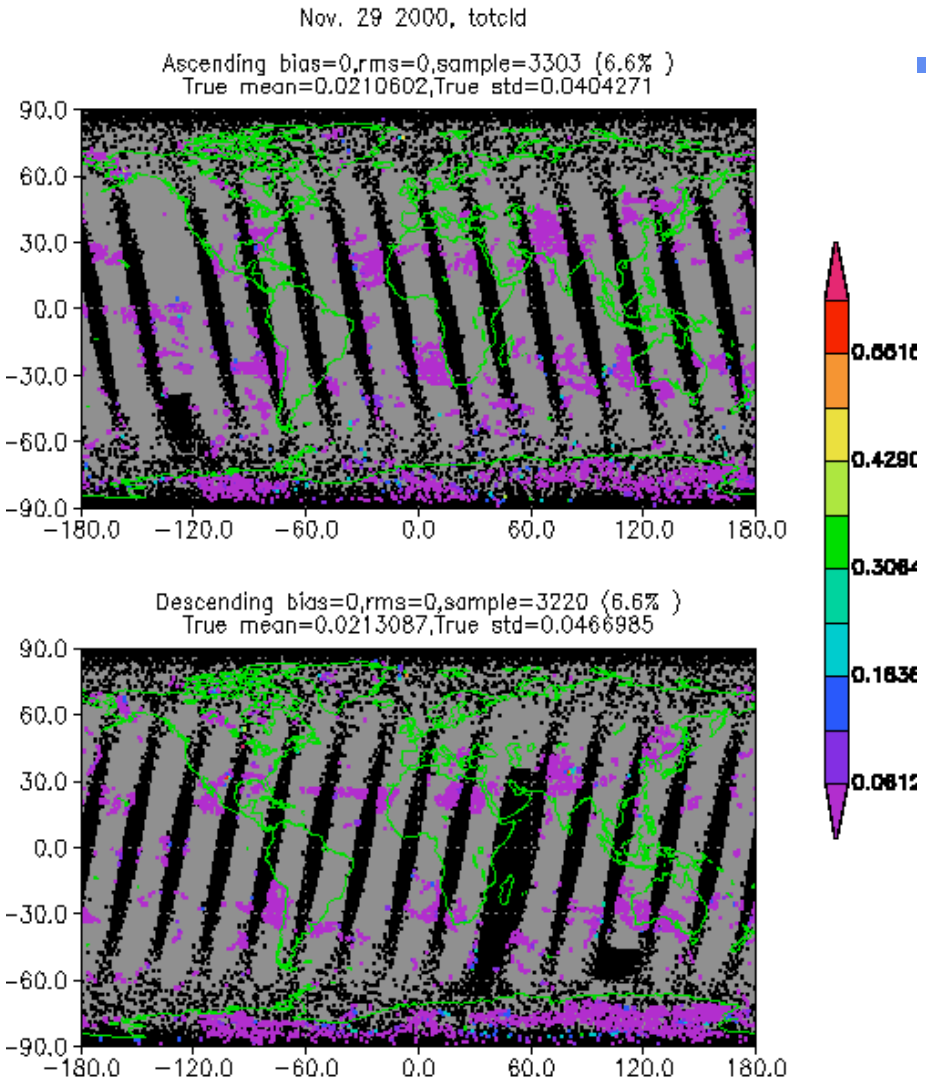
- Variability of 2390.910 radiance within 3x3 < 0.0026

Limitations

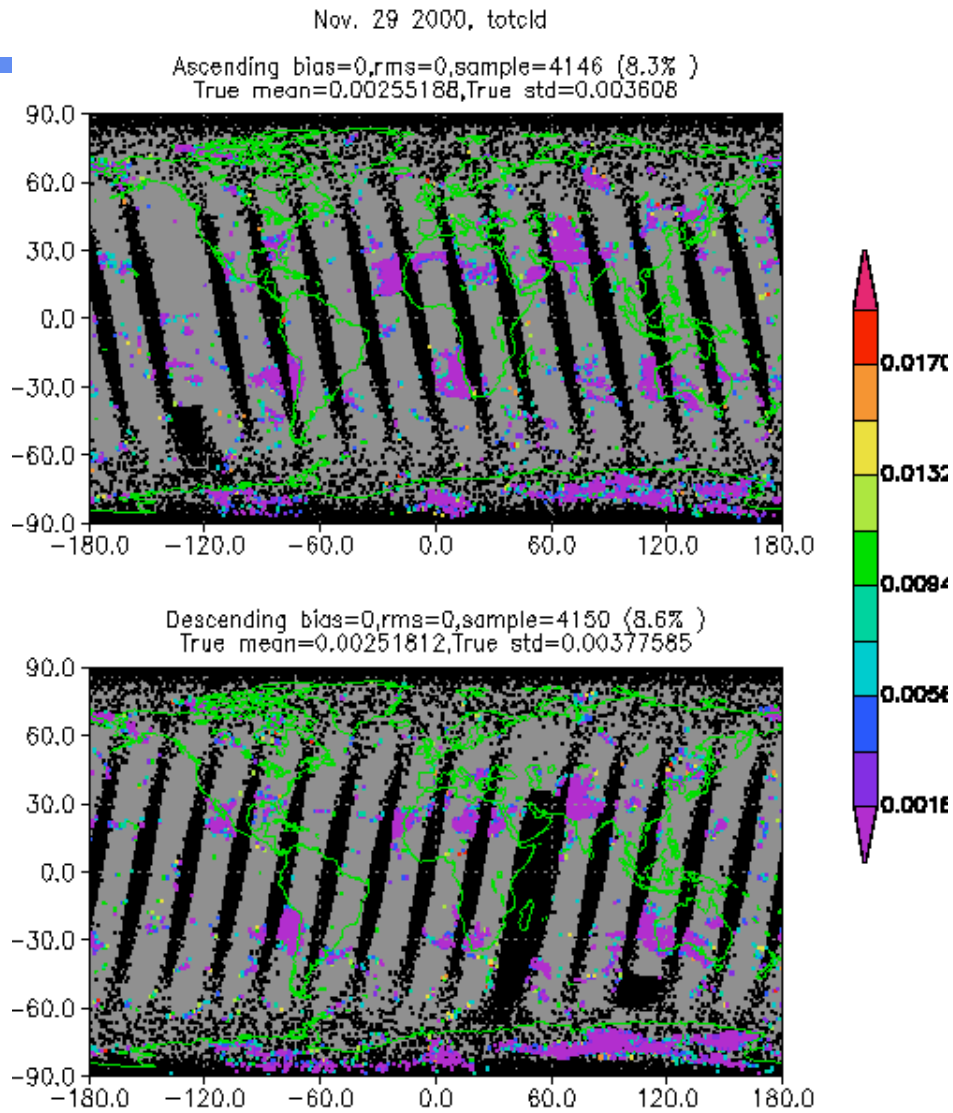
- Simulations have random cloud emissivities – spectrally uncorrelated.

- So cannot investigate spectral cloud signatures to identify clouds. (mean = 0.98 , sdv = .01)

Total cloud (3 tests)



True clear (< 2%)



Improvements to cloud detection

- Shortwave window channels compared to longwave window channels are more sensitive to clouds due to non-linearity of Planck function in the case of partly cloudy situations.
- At night shortwave and longwave windows for overcast conditions will be similar.
- During day reflected solar allows detection of clouds. (easier to detect clouds during the day)
- Predicting shortwave window channels from longwave is very useful. Coefficients derived from clear.

Predicting SST from 11 and 8 micron channels

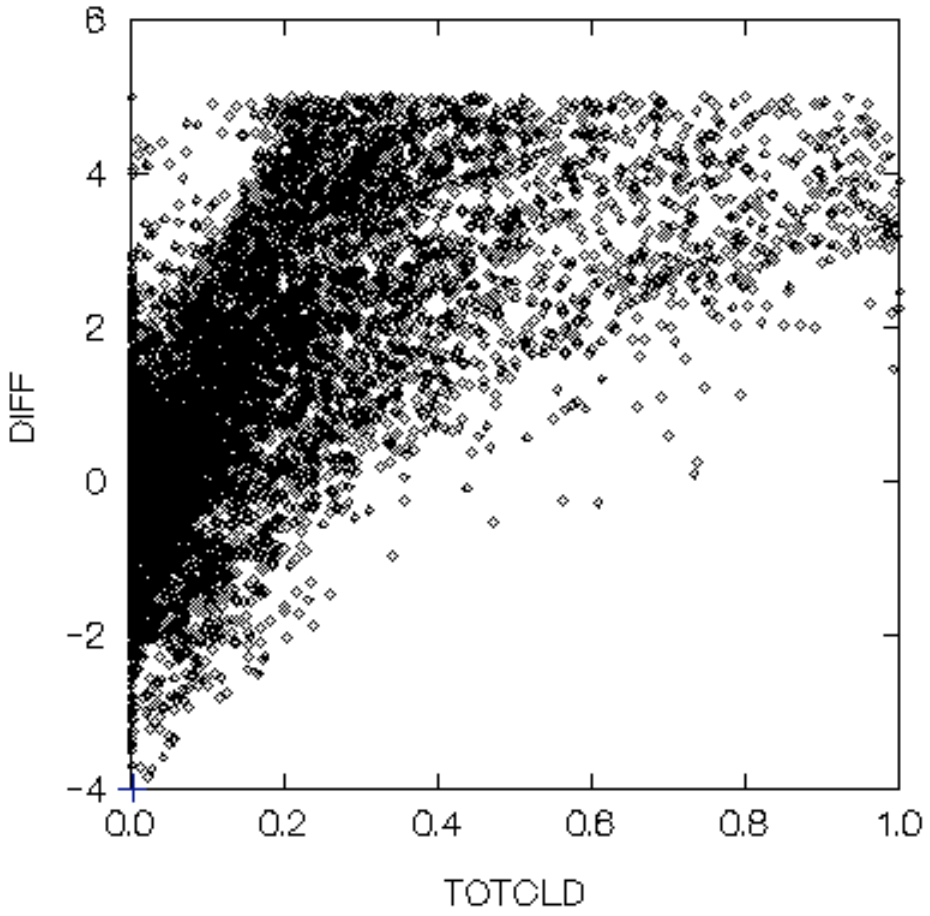
- SST from 918.65, 965.32, 1228.09, 1236.40

- DEP VAR: SURFT N: 2289 MULTIPLE R: 1.000 SQUARED MULTIPLE R: 0.999
- ADJUSTED SQUARED MULTIPLE R: .999 STANDARD ERROR OF ESTIMATE: 0.23695

- VARIABLE COEFFICIENT STD ERROR STD COEF TOLERANCE T P(2 TAIL)

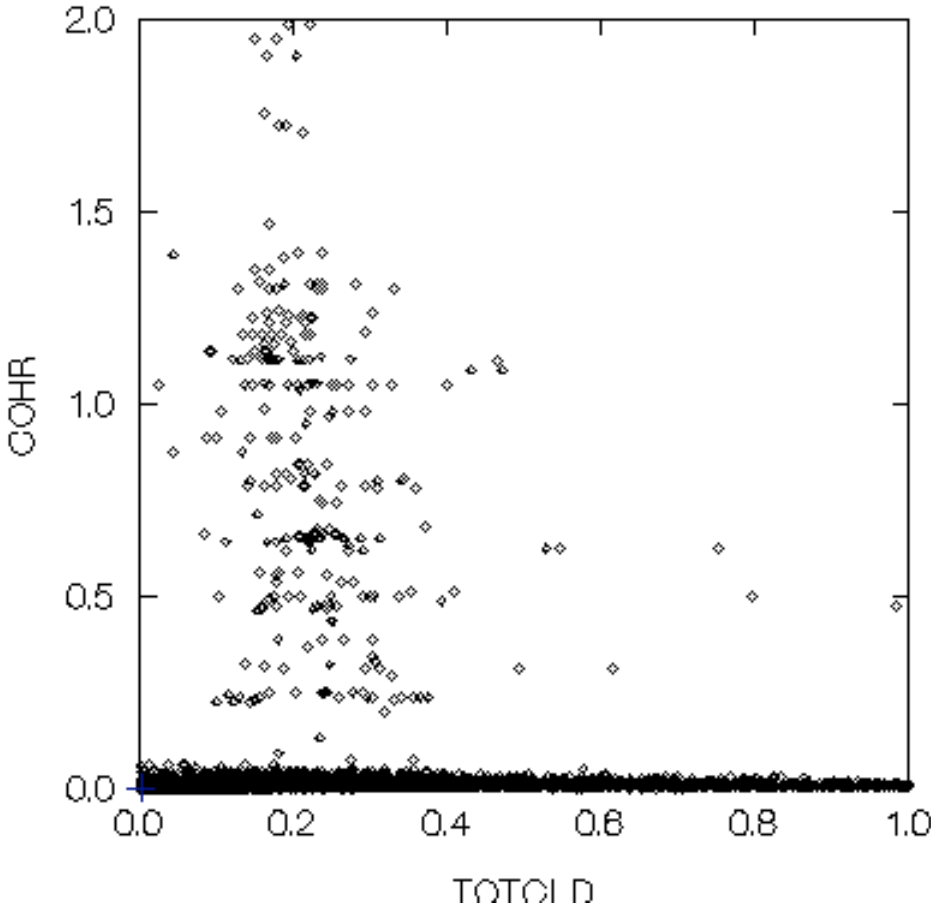
- CONSTANT 8.28206 0.26327 0.00000 . .31E+02 0.00000
- LWO(26) -0.97957 0.01436 -0.85447 0.00243 -.68E+02 0.00000
- LWO(29) 0.60529 0.05165 0.56538 0.00016 .12E+02 0.00000
- MWO(65) 1.74444 0.05713 1.60310 0.00014 .31E+02 0.00000
- MWO(66) -0.40379 0.00929 -0.32981 0.00663 -.43E+02 0.00000

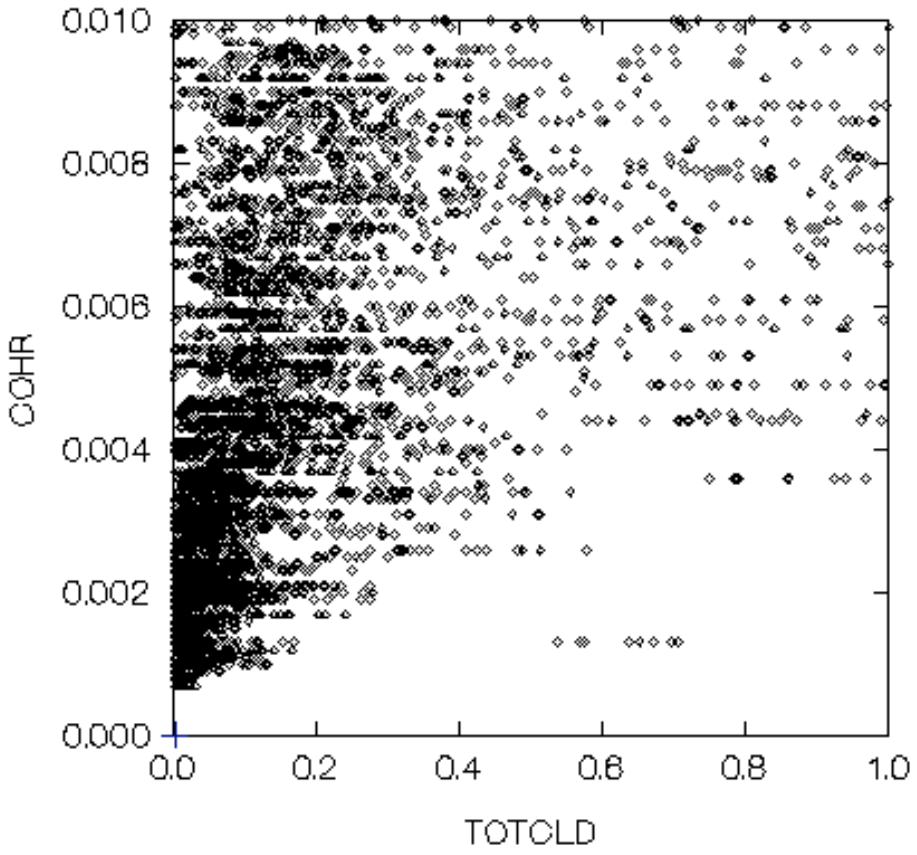
Scatter diagrams of cloud tests vs cloud amount
Night ocean Granule 401 December 15, 2000



Predicted AIRS 2390 – Observed

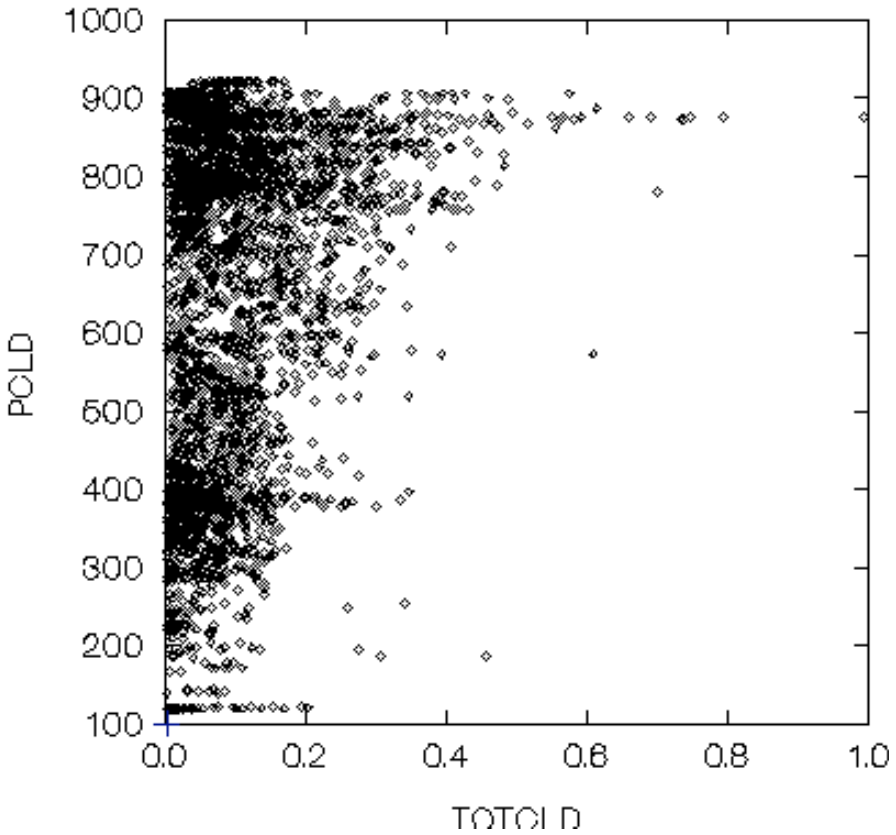
3 x 3 spatial coherence test of 2390 cm-1 channel



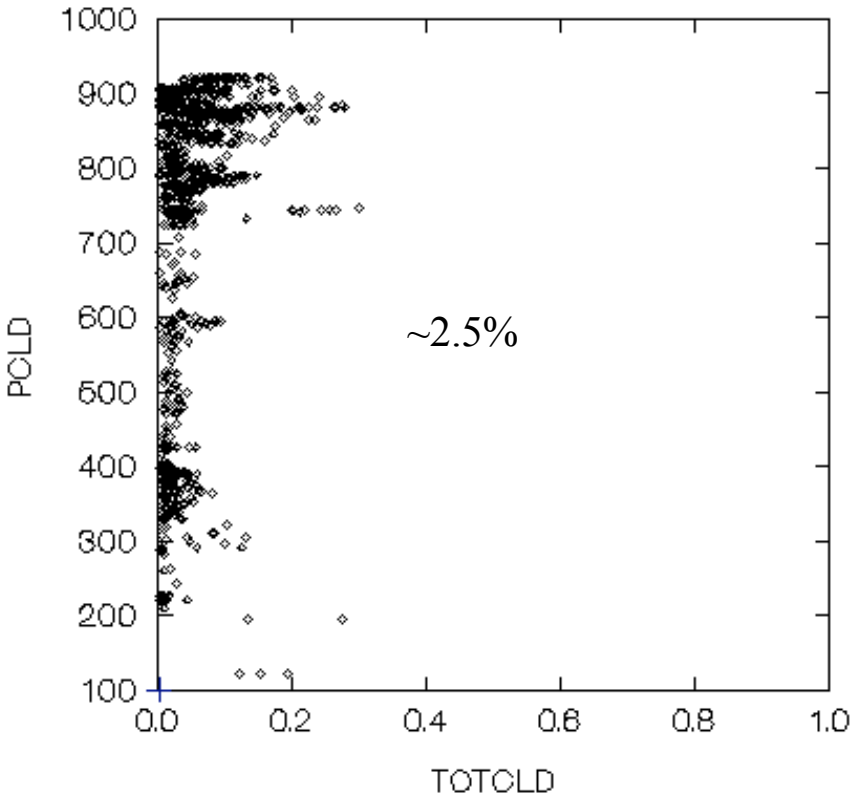


Cloud pressure vs. Cloud amount for original cloud tests residual error is 2.5% -- need better tests

Predicted AIRS from AMSU



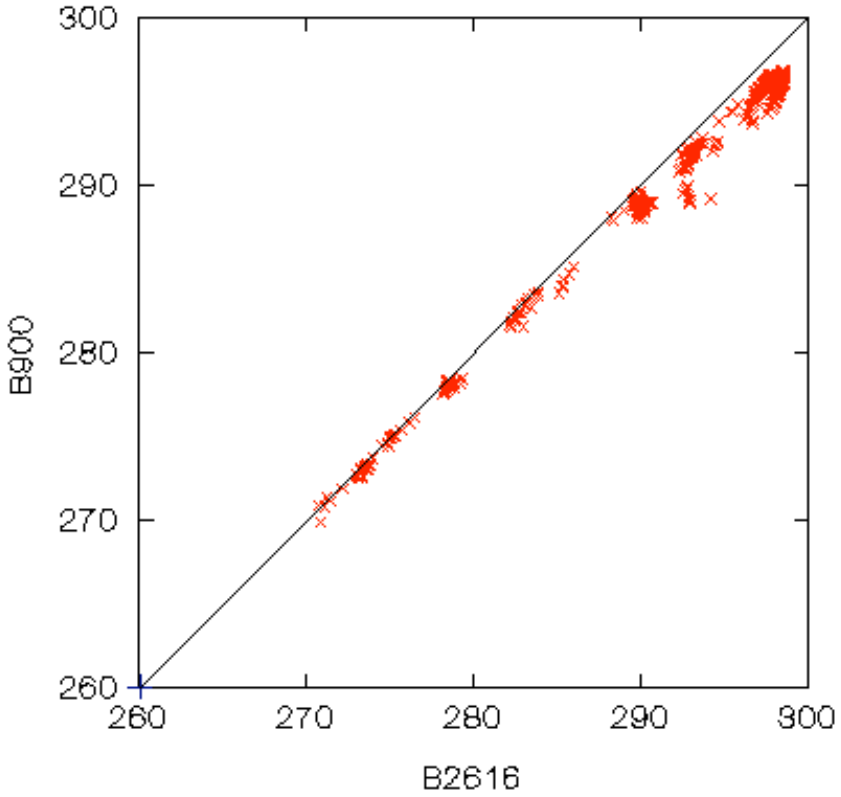
and adding coherence test

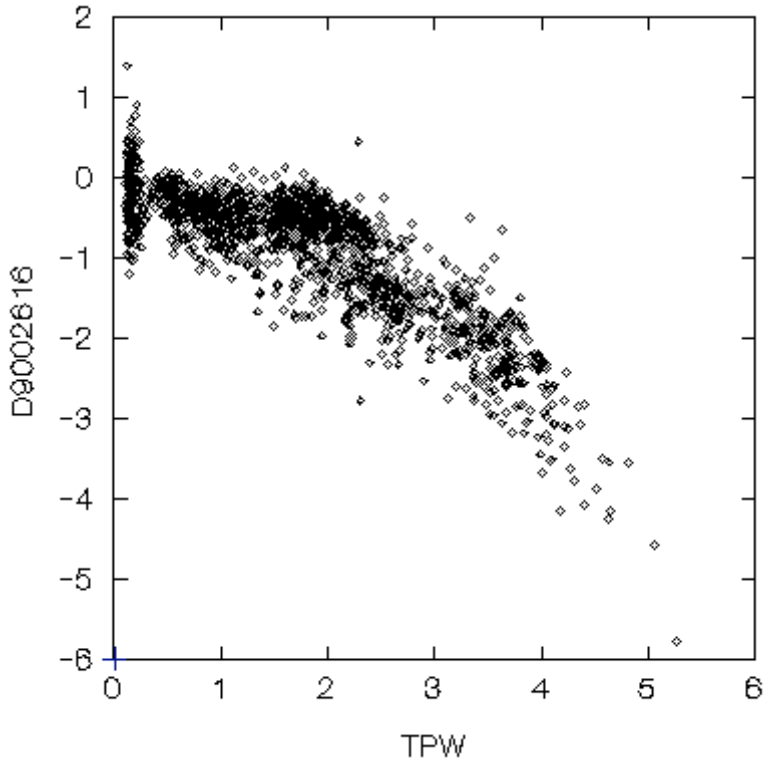


Improved Cloud Detection

- Better tests are derived by predicting 2616 cm-1 channel from 11 or 8 micron channels.
- Comparing SST with 2616 at Night.
- Predicting SST from 11 and 8 micron channels (works for day and night)

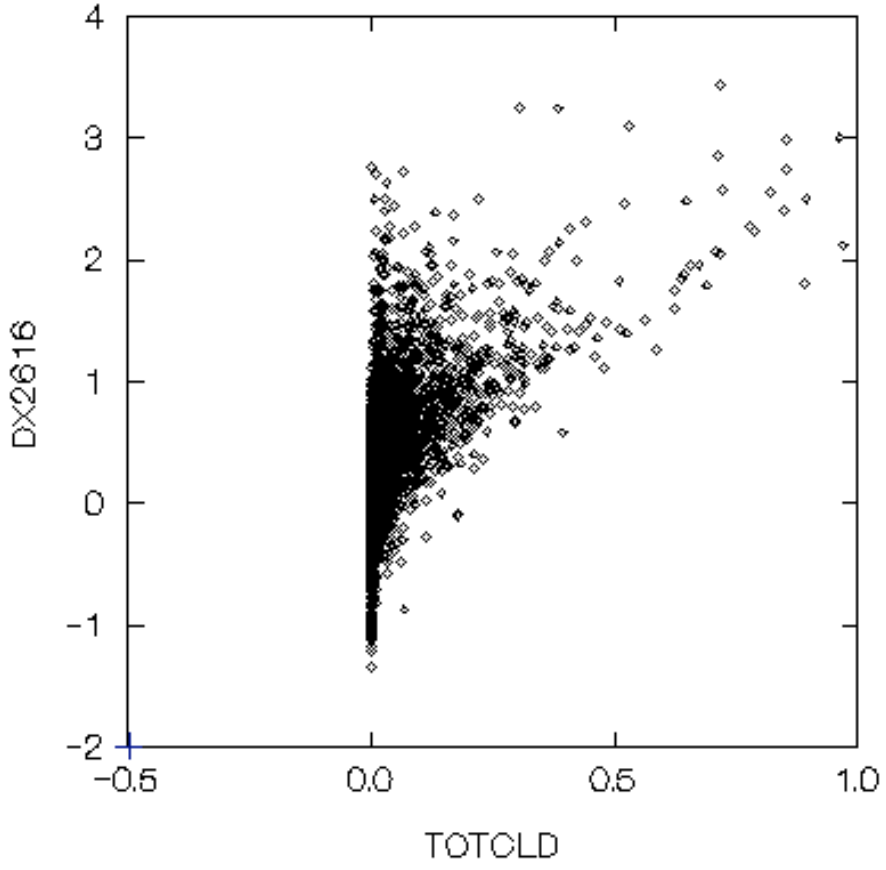
Can compare 900 cm-1 with 2616, but highly dependent on TPW



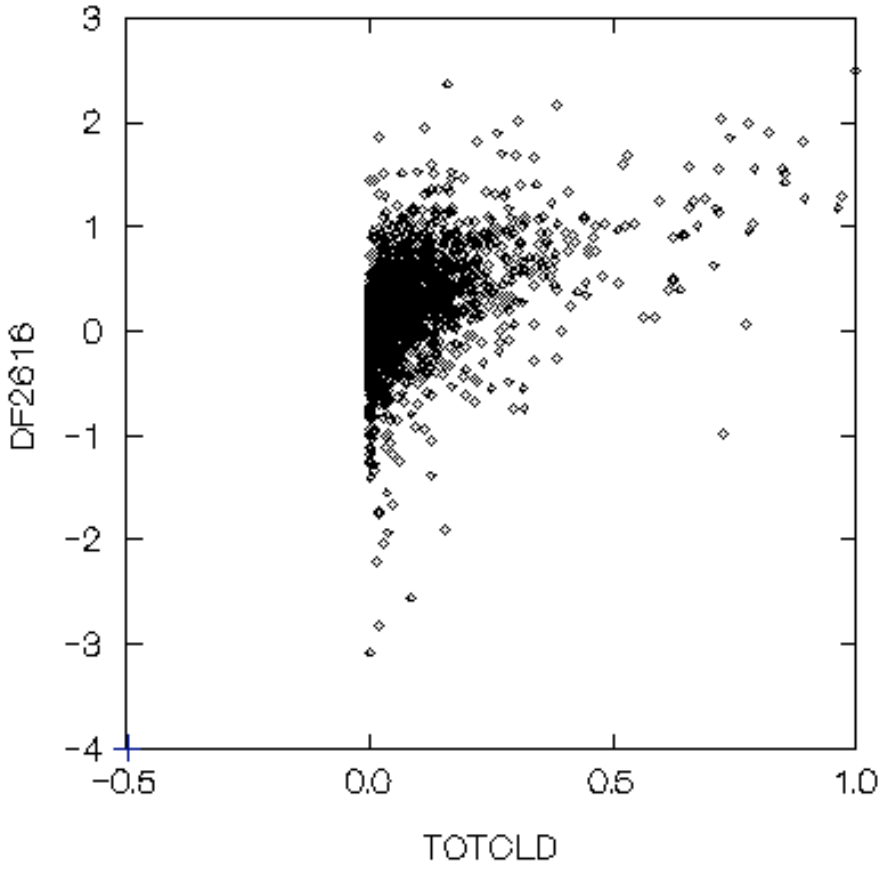


A solution is to predict 2616 from longwave channels

Predicting 2616 from 8 micron (rms = .5)



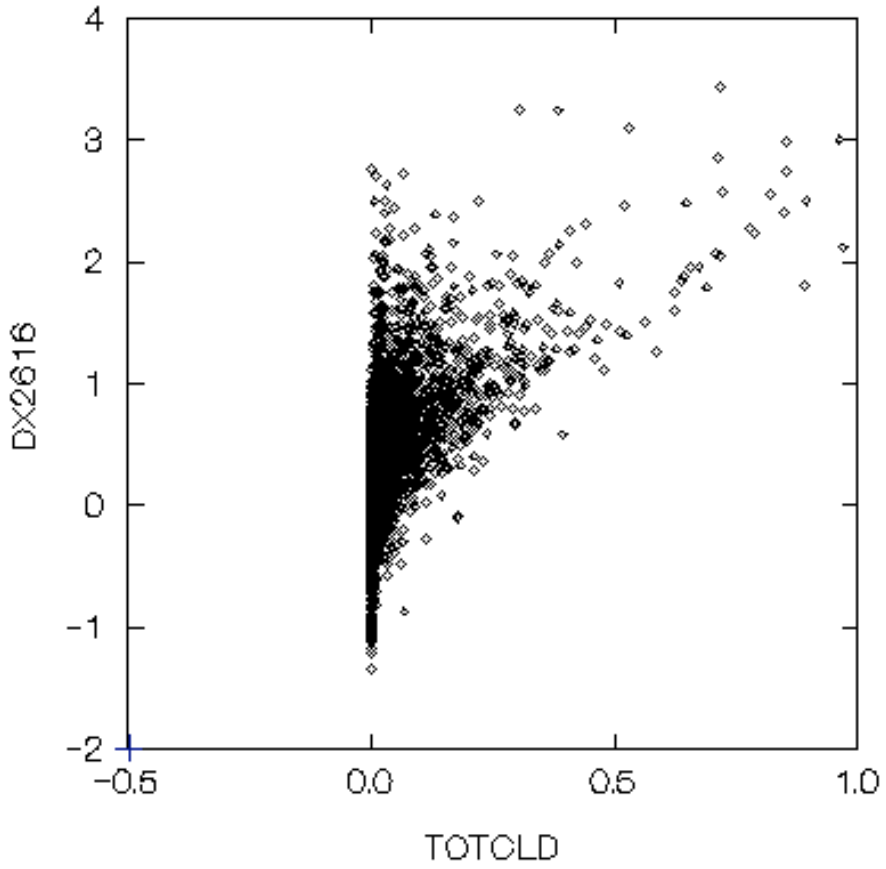
from 8 and 11 (rms = .2)



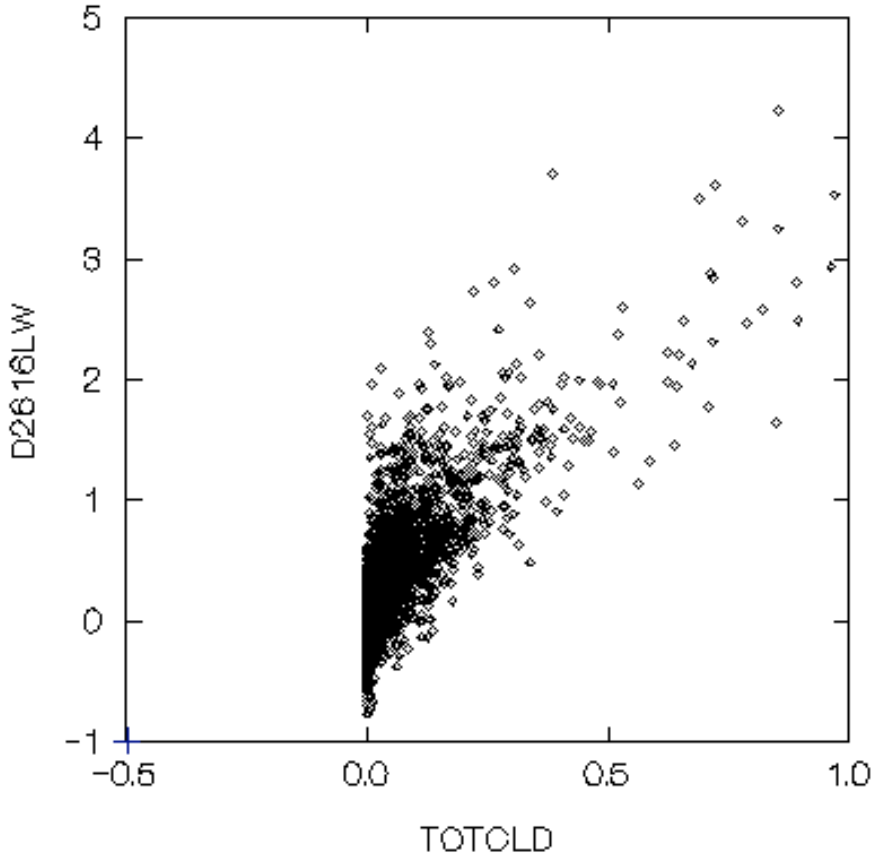
Observed minus predicted vs. Total cloud amount

Results are better if predictor channels are limited to a small spectral region
11 or 8 micron not 11 and 8 micron (see previous slide)

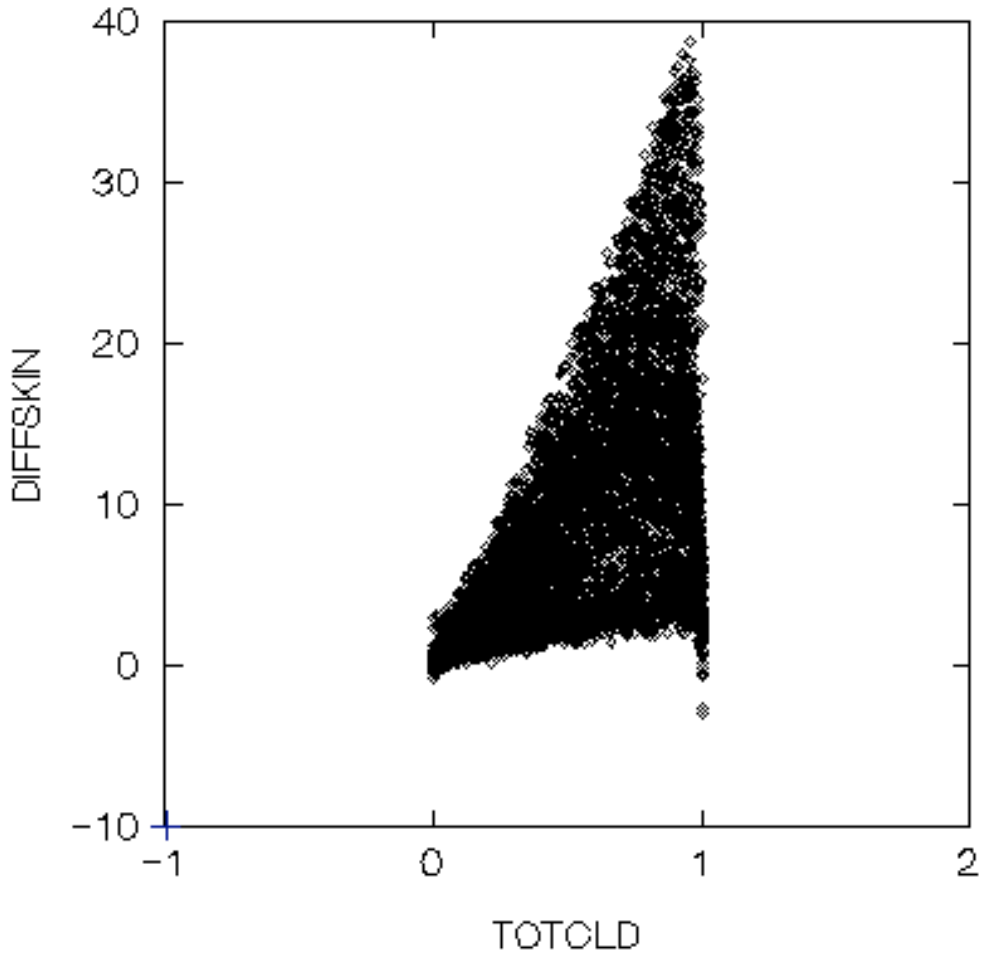
Predicting 2616 from 8 micron (rms = .5)



from 11 micron (rms = .2)

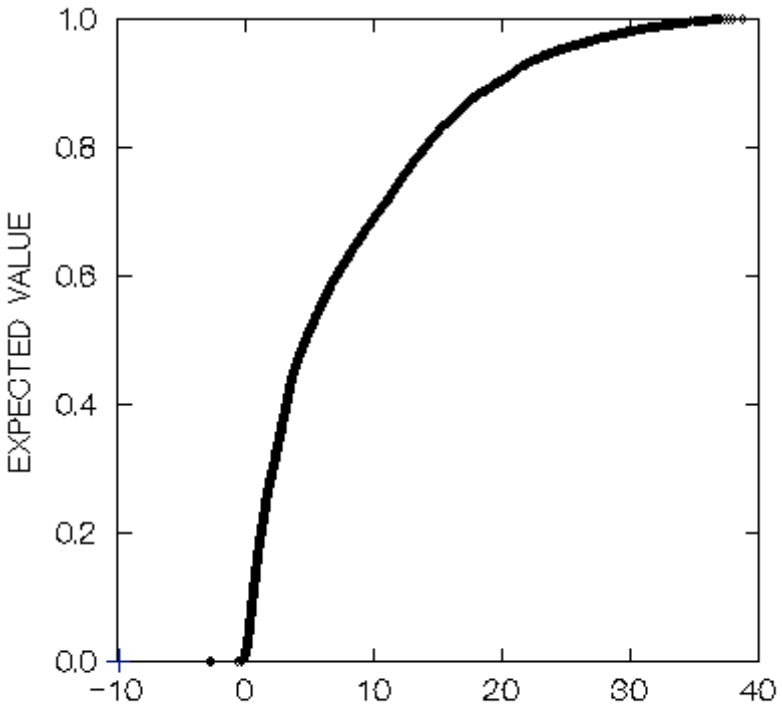


Observed 2616 minus predicted vs. total cloud fraction

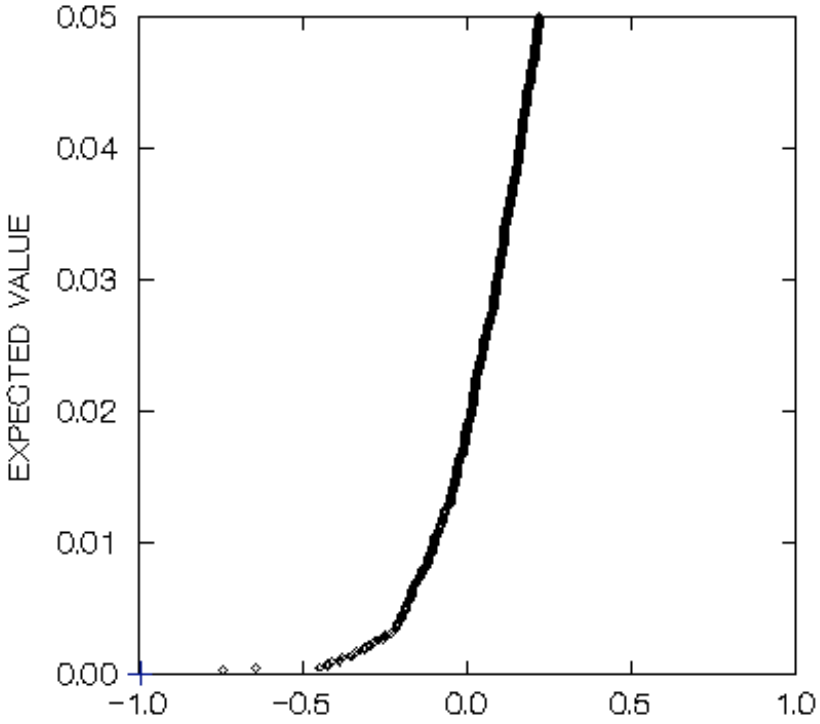


Select threshold by using cumulative distribution function and assume that 5% of globe is clear.

Threshold ~ 0.2 K



Observed 2616 minus predicted 2616 BT

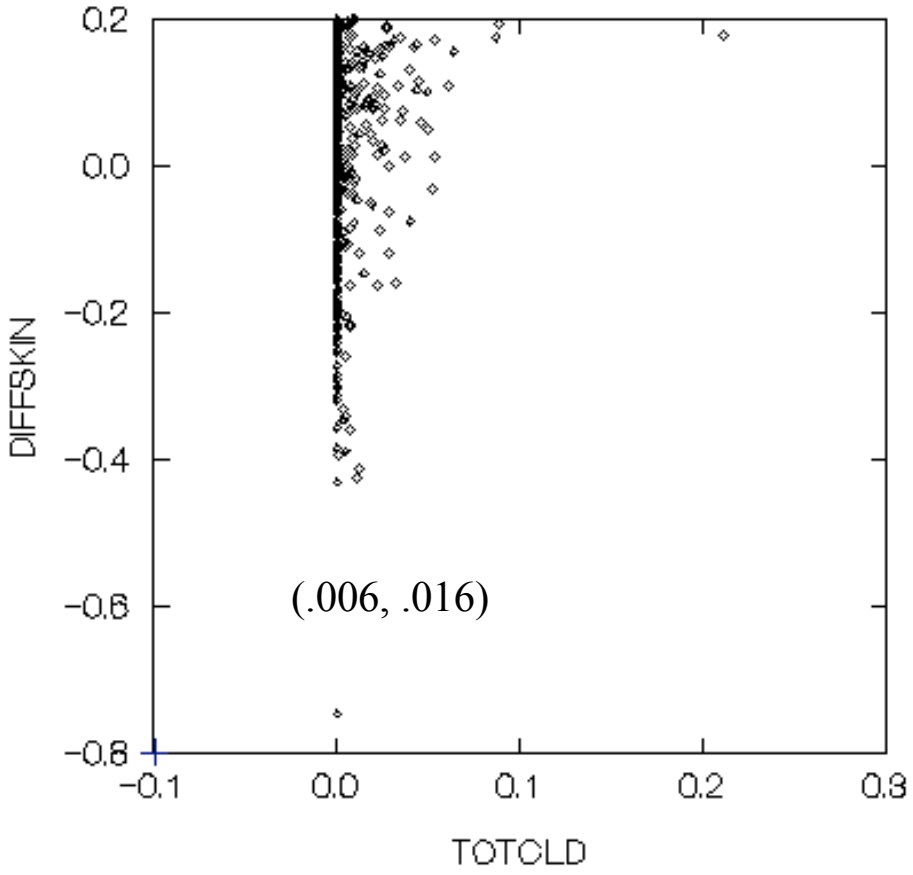


Observed 2616 minus predicted 2616 BT

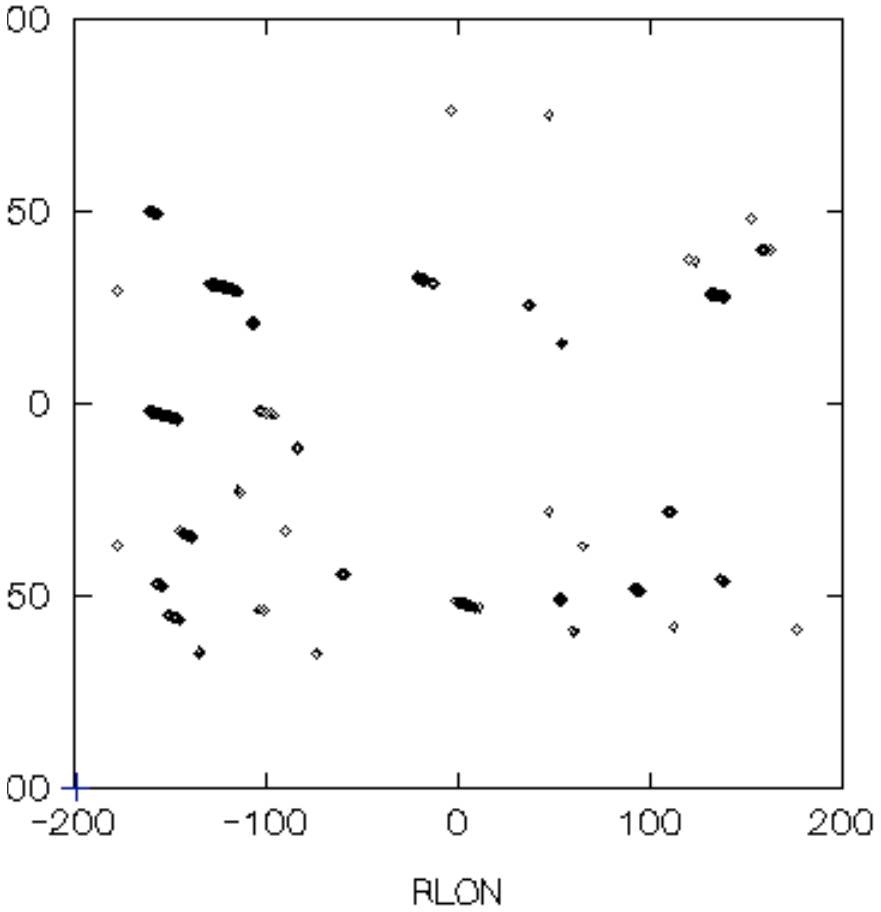
Predict 2616 from 8 micron channels (4 channels) and if observed 2616 minus predicted < .2 then the fov is clear.

Residual bias error is 0.6% with rms of 1.6% cloud amount

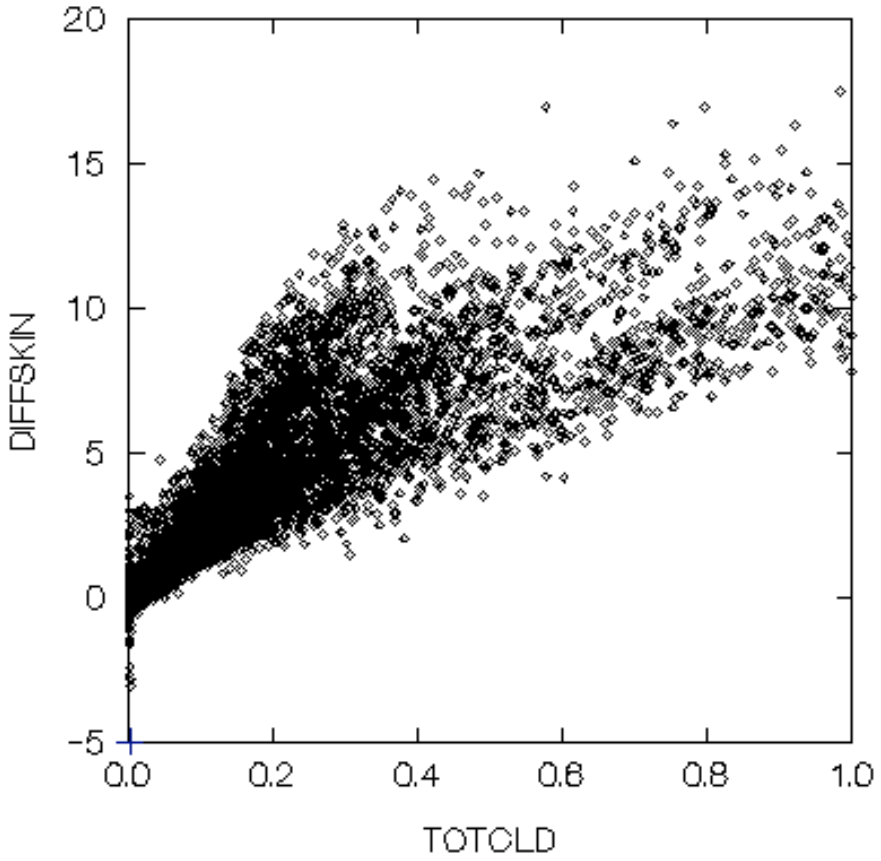
Observed minus predicted vs. cloud amount



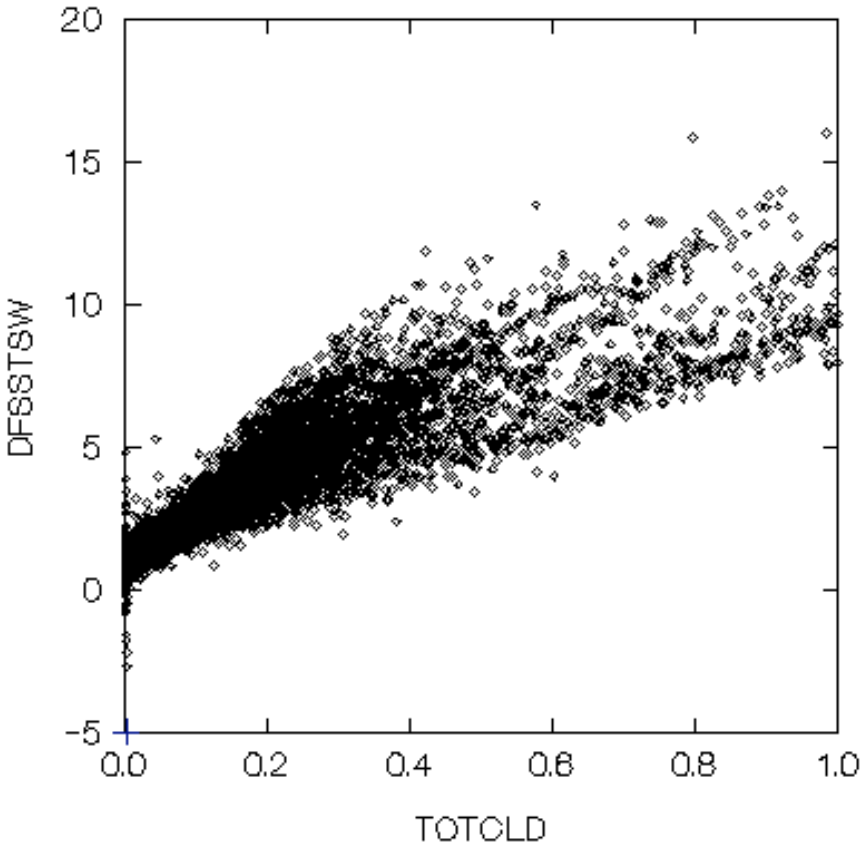
Locations of clear fovs



To get rid of residual clouds, the use of NCEP SST is very important

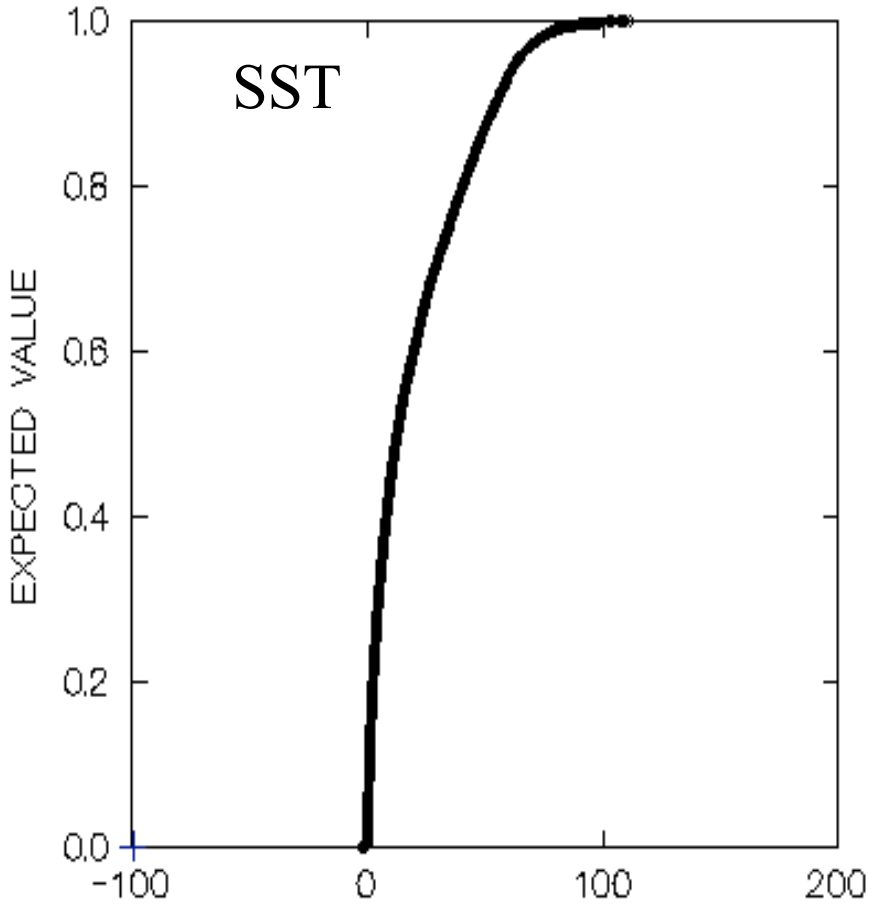


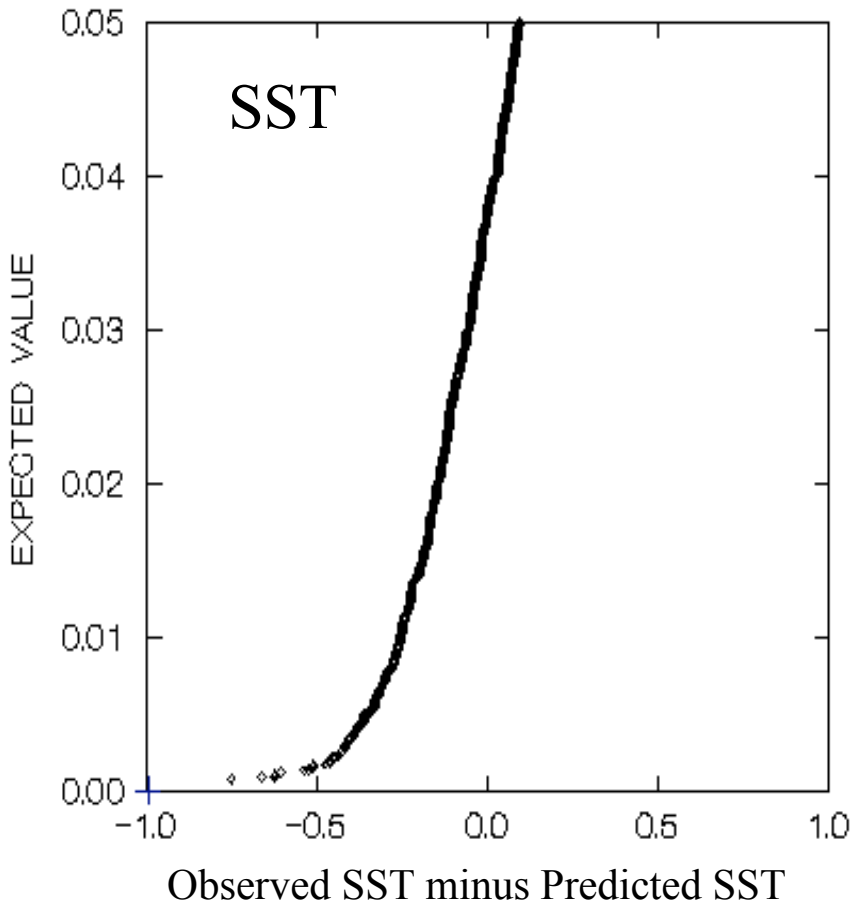
SST - Predicted SST



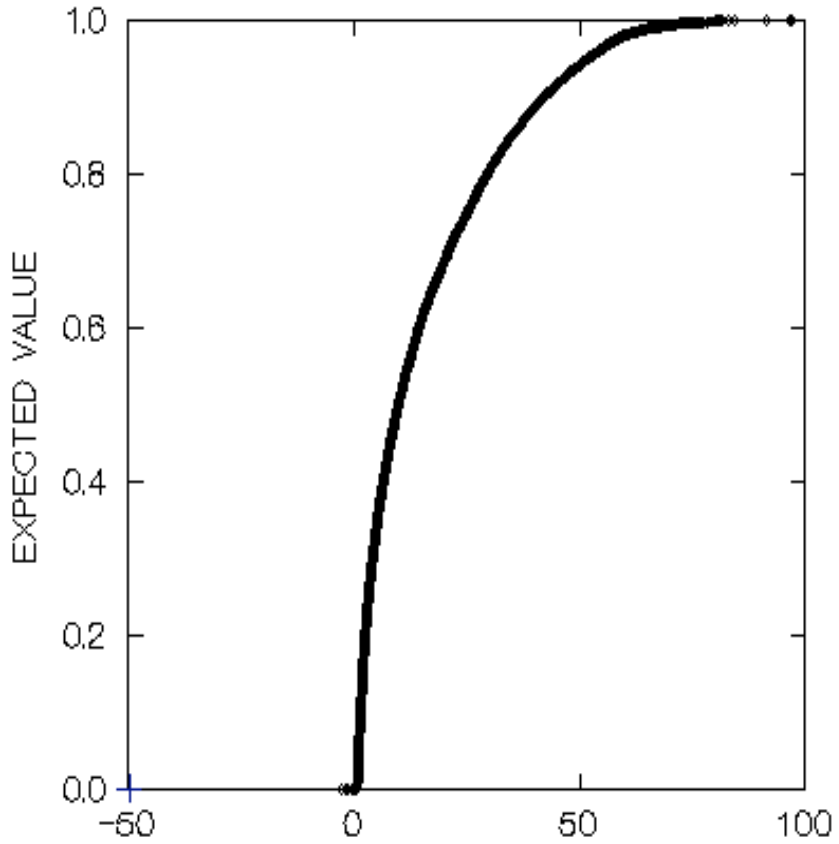
SST - 2616

Approach to selecting “good” threshold : use cumulative probability distribution

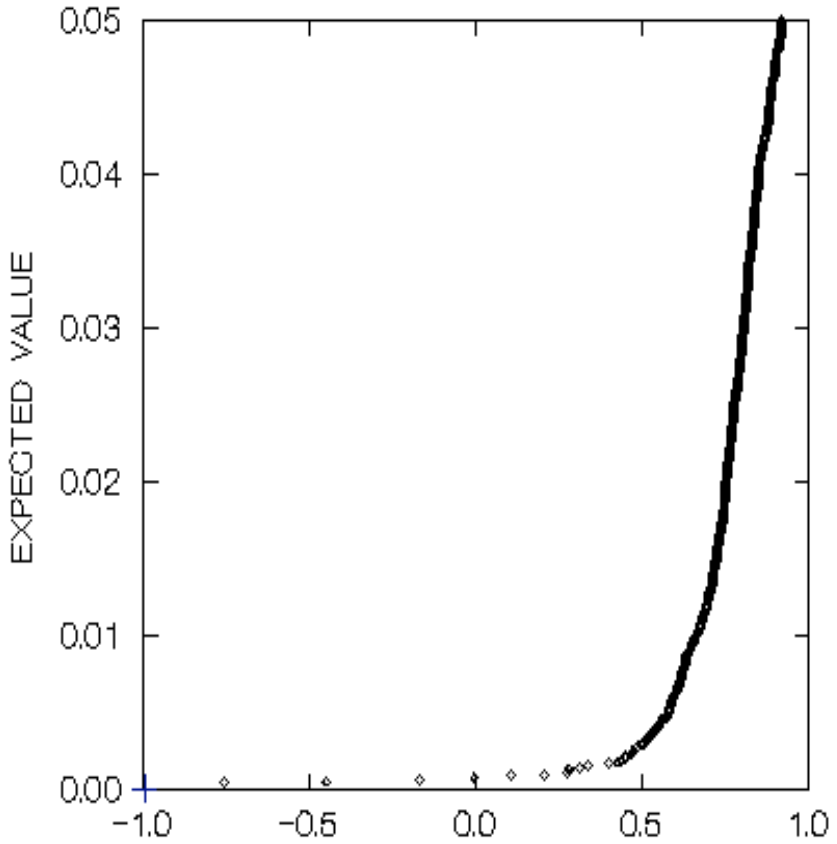




Cumulative distribution function for SST minus 2616



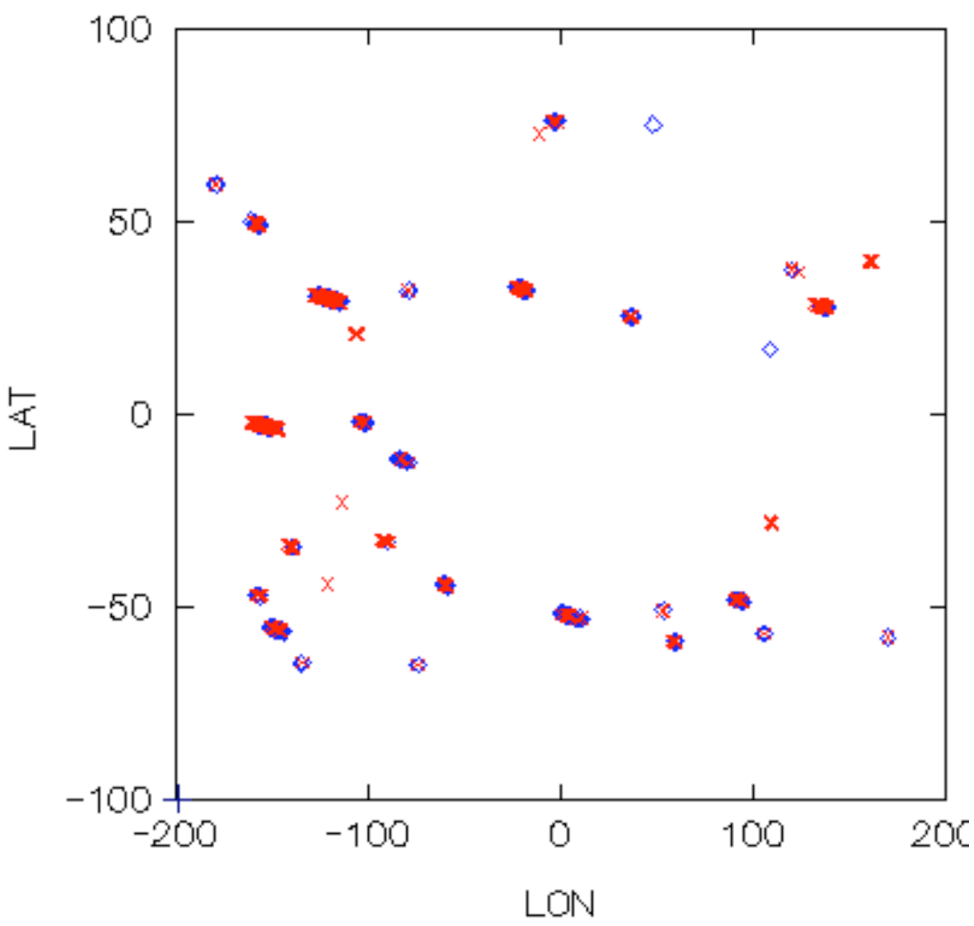
Observed SST minus 2616 BT

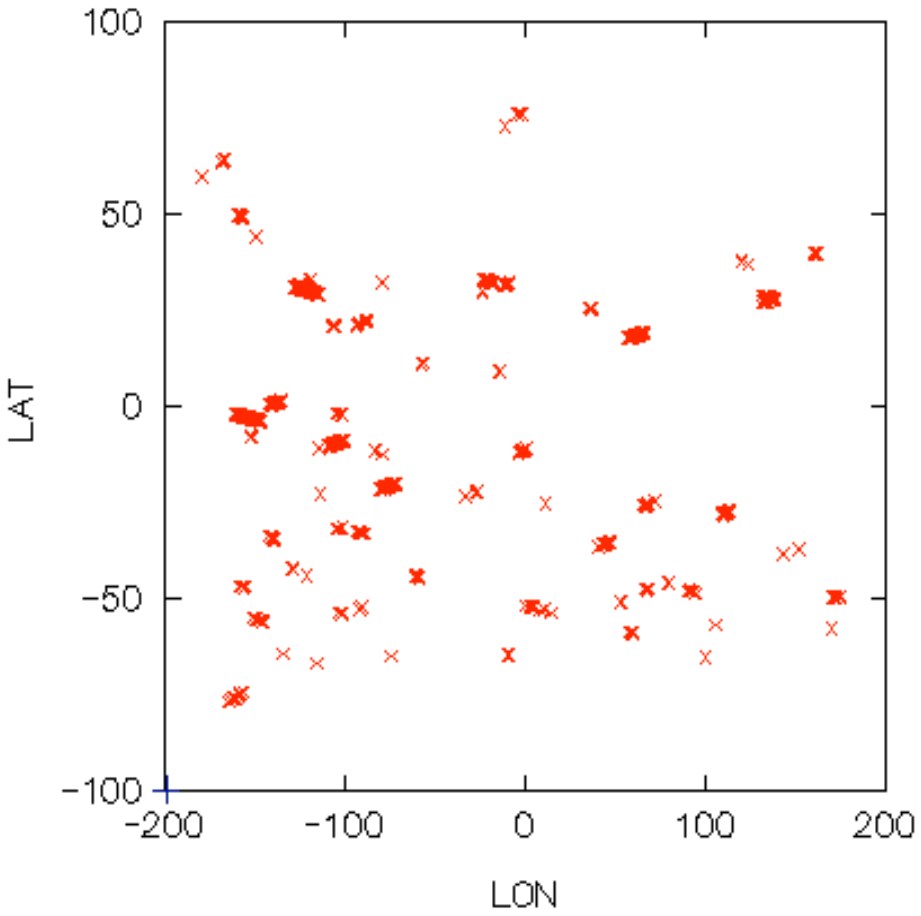


Observed SST minus 2616 BT

Location of detected clear locations

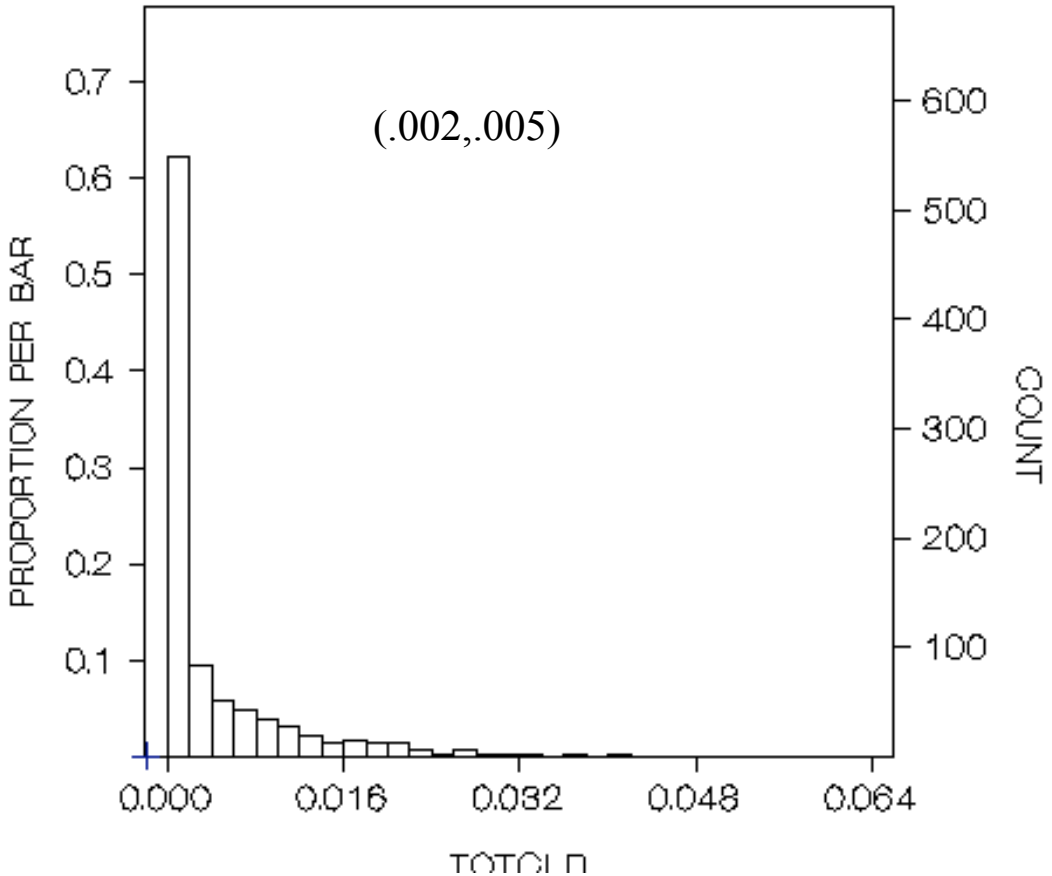
Blue = 2616 approach, Red = predicting SST approach





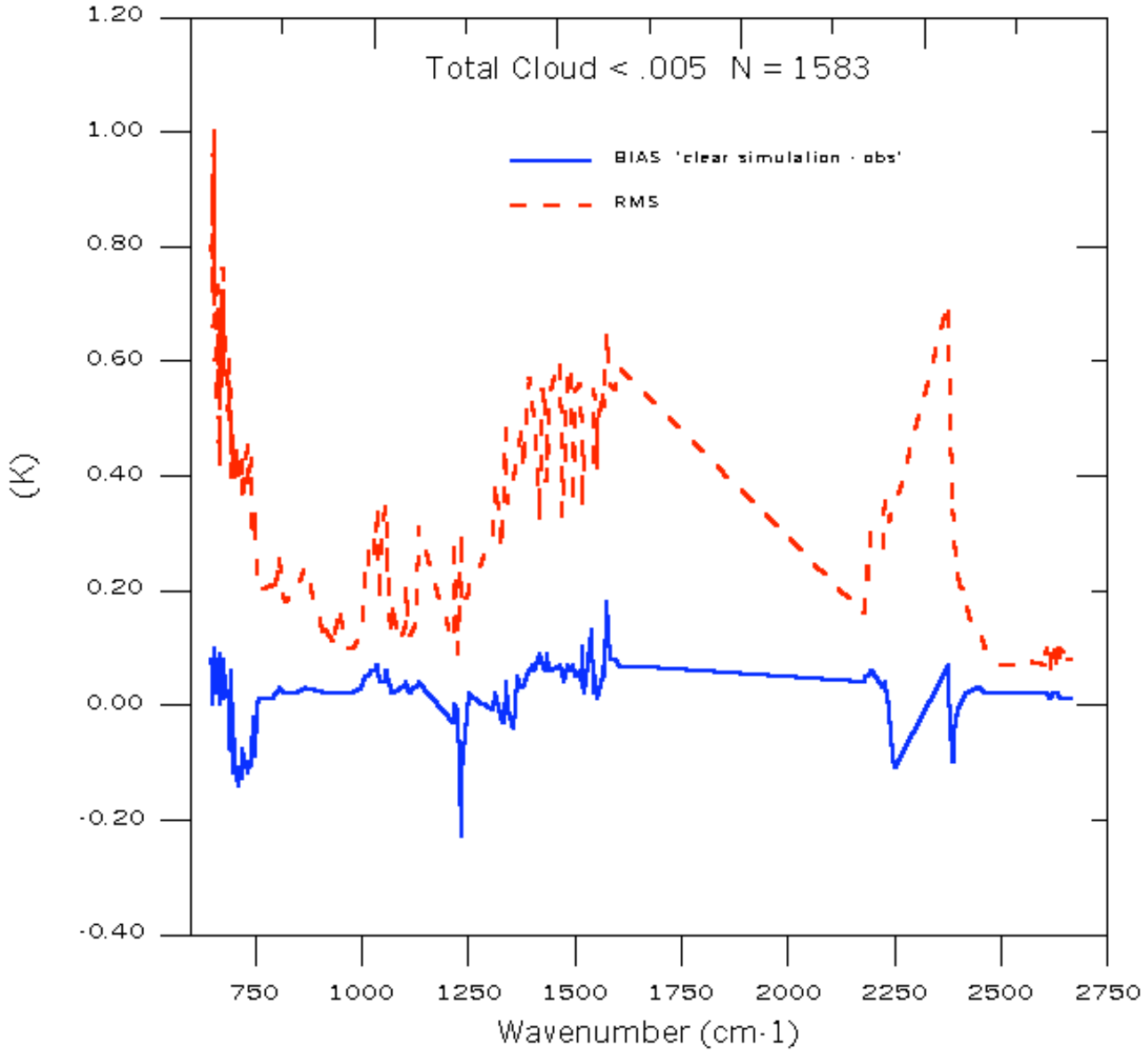
Histogram of actual cloud amount for detected clear cases (observed SST – predicted < 0.2 K)

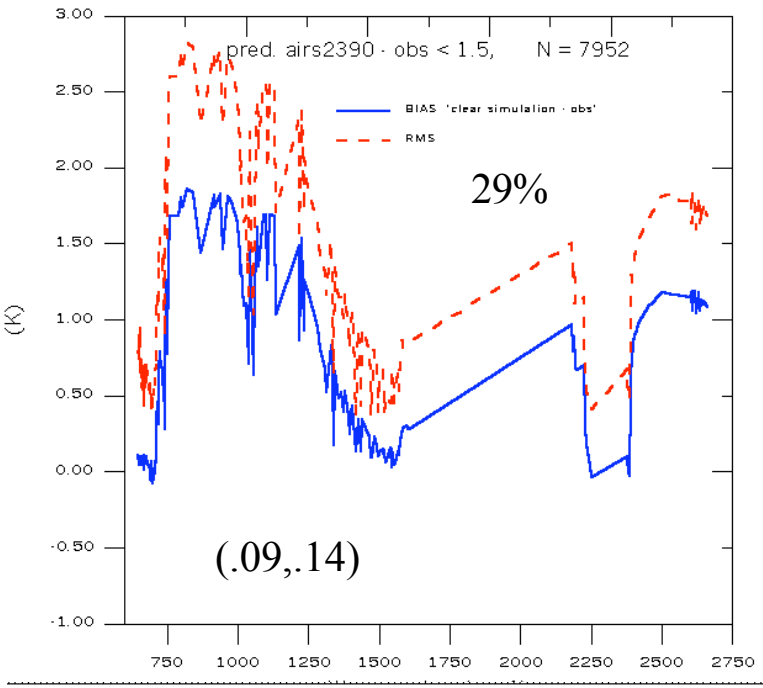
Residual bias = 0.2 %, rms = 0.5 %

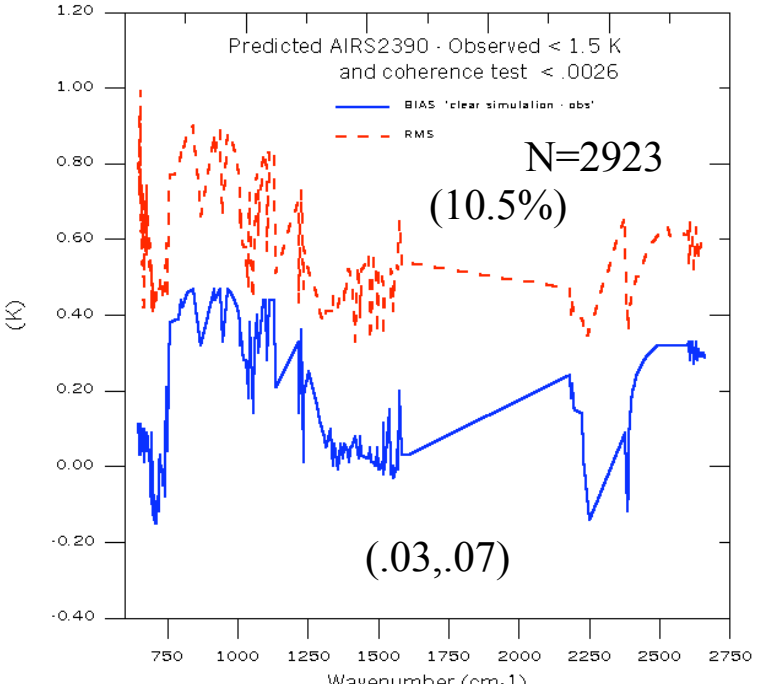


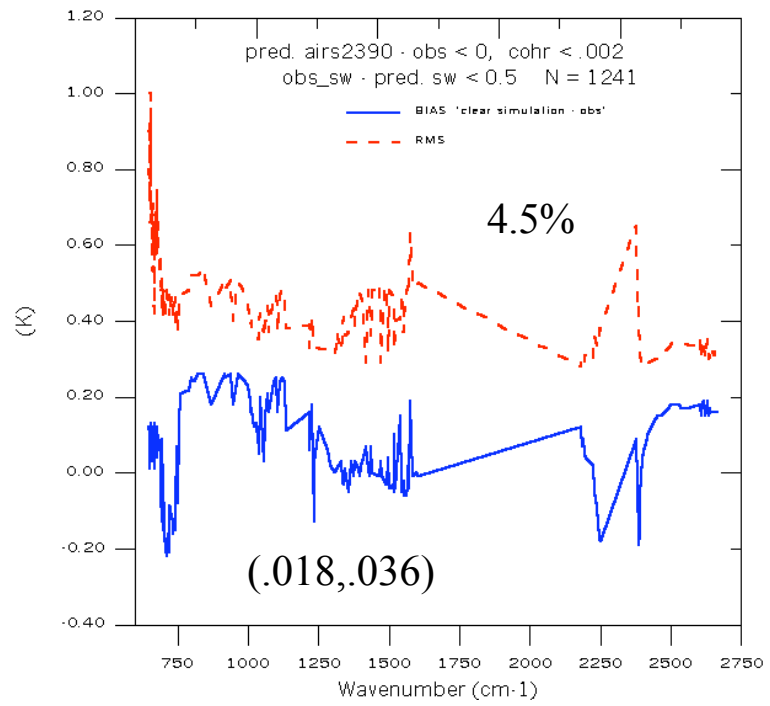
Clear simulated vs. observed results

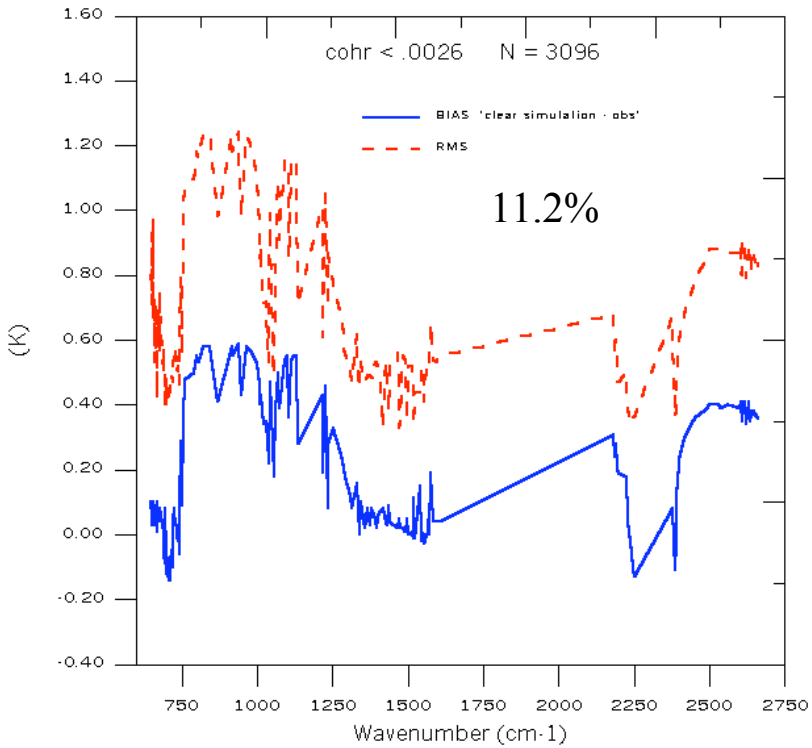
- December 15, 2000
- Radiances generated from NESDIS NRT system with clouds.
- Cloud detection coefficients generated from December 10, 2000
- Use Larrabee's code to simulated radiances from NESDIS global grids of NCEP forecast (truth)
- NRT system produce 1x1 global grids of truth, 281 channel subset and principal components.

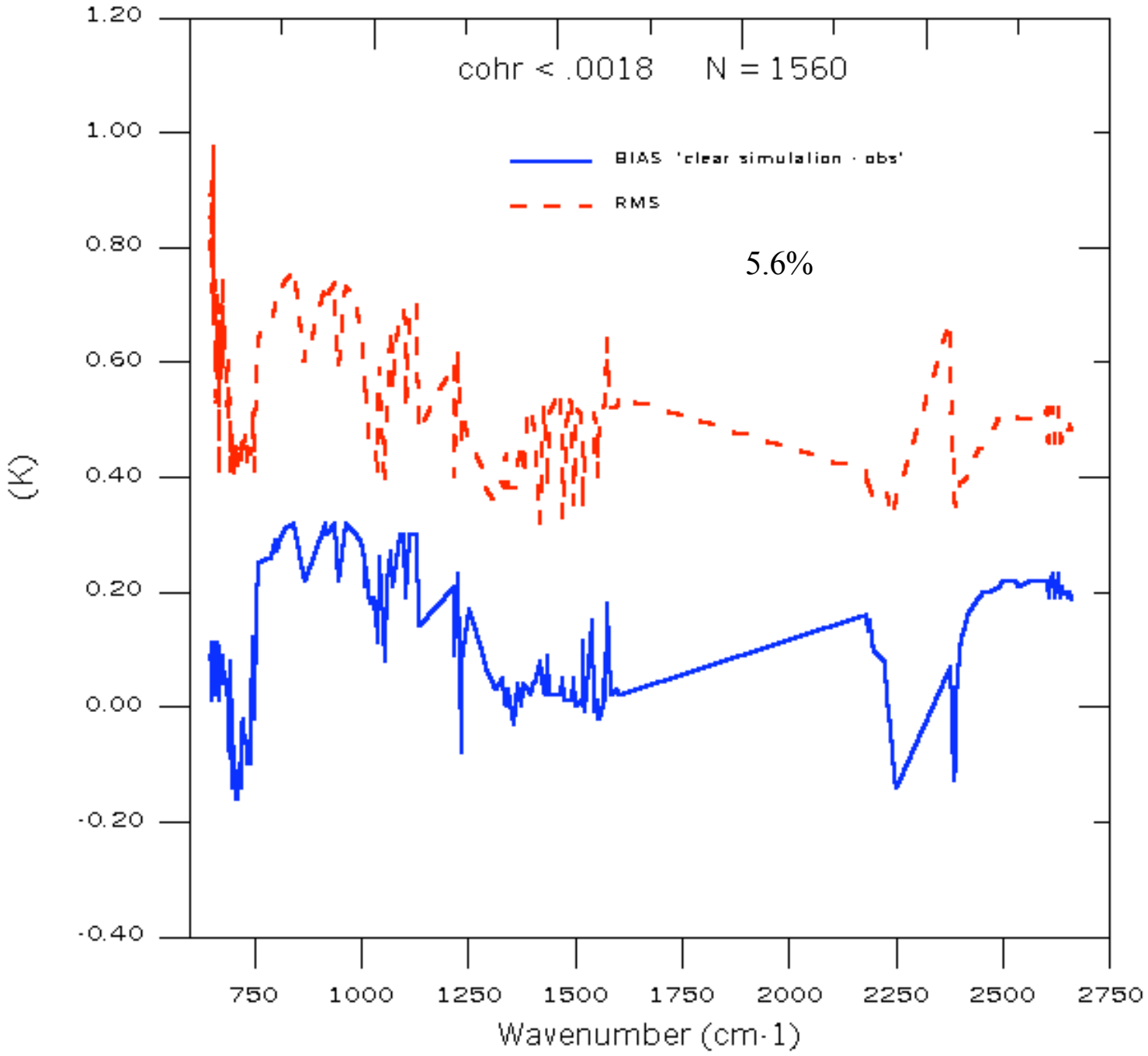

Total Cloud < .005 N = 1583
BIAS 'clear simulation - obs'
RMS
(K)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
750
1000
1250
1500
1750
2000
2250
2500
2750
Wavenumber (cm-1)

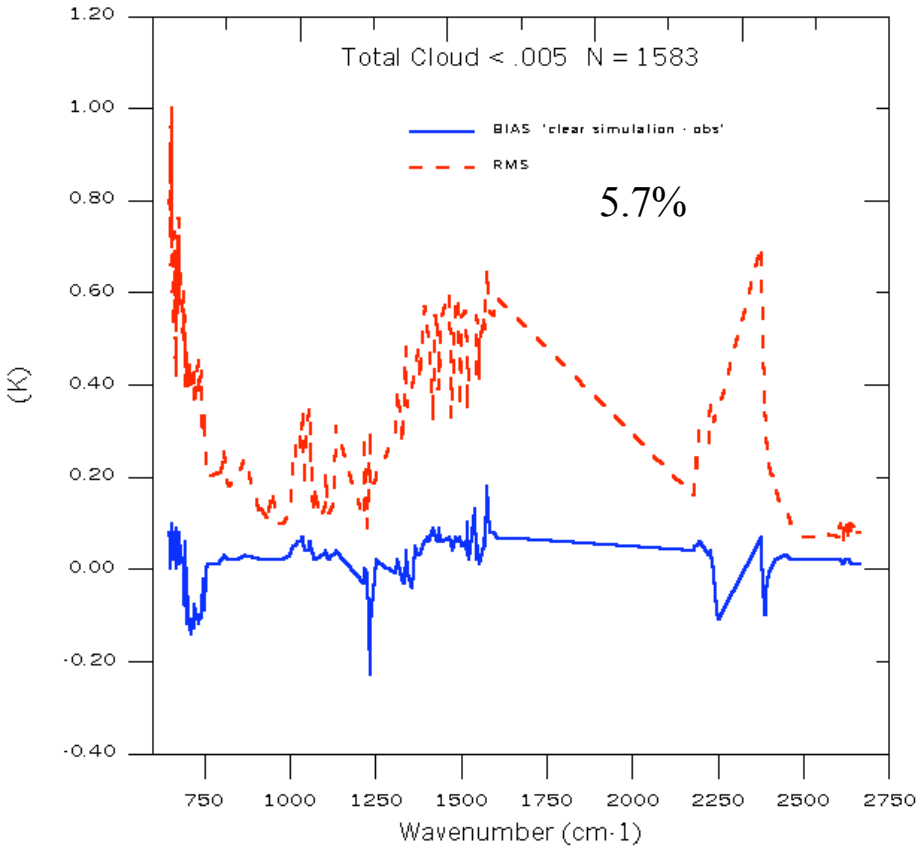

pred. airs2390 - obs < 1.5, N = 7952
BIAS 'clear simulation - obs'
RMS
29%
(.09,.14)
(K)

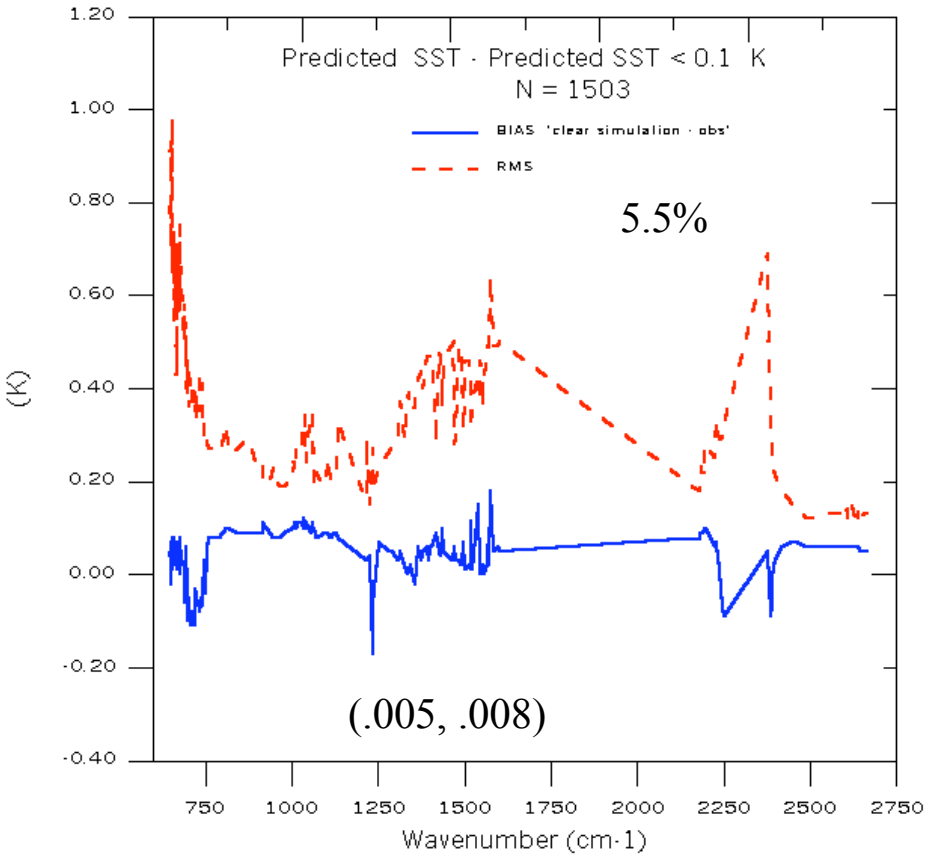

Predicted AIRS2390 - Observed < 1.5 K
and coherence test < .0026
BIAS 'clear simulation - obs'
RMS
N=2923
(10.5%)
(.03,.07)
(K)


pred. airs2390 - obs < 0, cohr < .002
obs_sw - pred. sw < 0.5 N = 1241
BIAS 'clear simulation - obs'
RMS
4.5%
(.018,.036)
(K)
Wavenumber (cm-1)


cohr < .0026 N = 3096
BIAS 'clear simulation - obs'
RMS
11.2%
(K)
Wavenumber (cm-1)


cohr < .0018 N = 1560
BIAS 'clear simulation - obs'
RMS
5.6%
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
(K)
750
1000
1250
1500
1750
2000
2250
2500
2750
Wavenumber (cm-1)

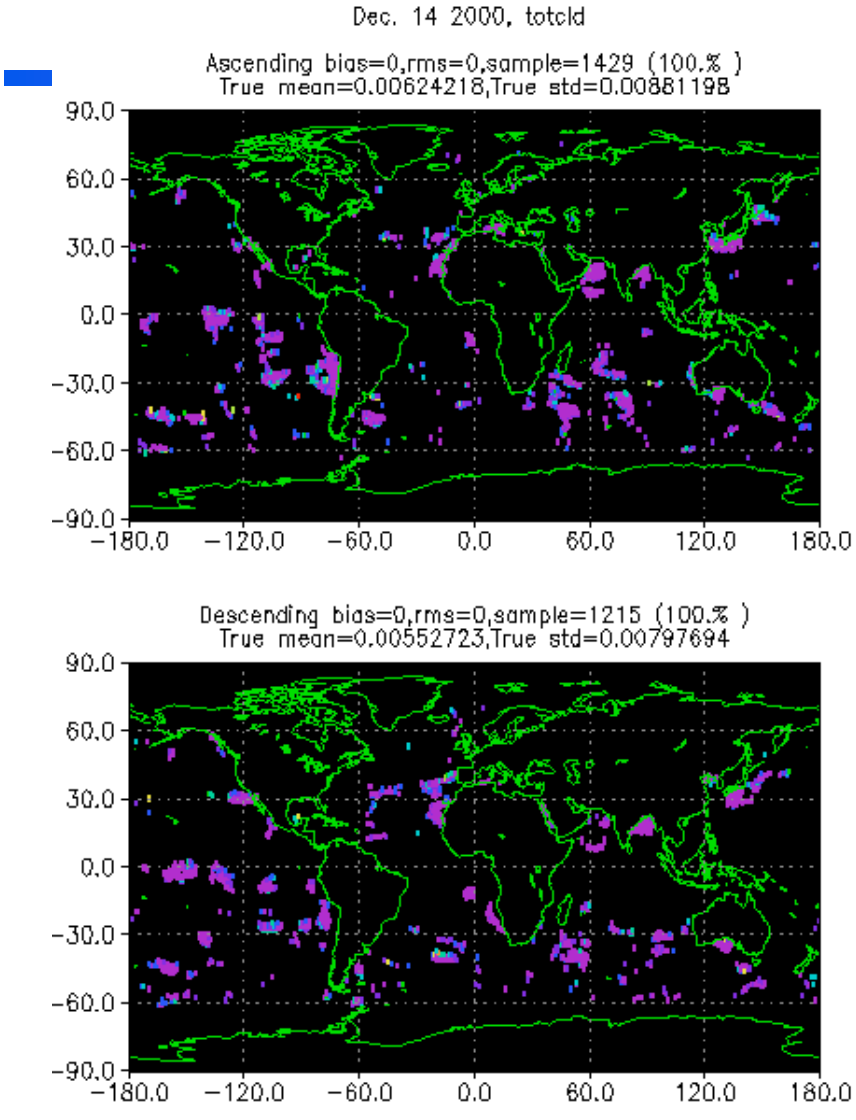

Total Cloud < .005 N = 1583
BIAS 'clear simulation - obs'
RMS
5.7%
(K)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
750
1000
1250
1500
1750
2000
2250
2500
2750
Wavenumber (cm-1)

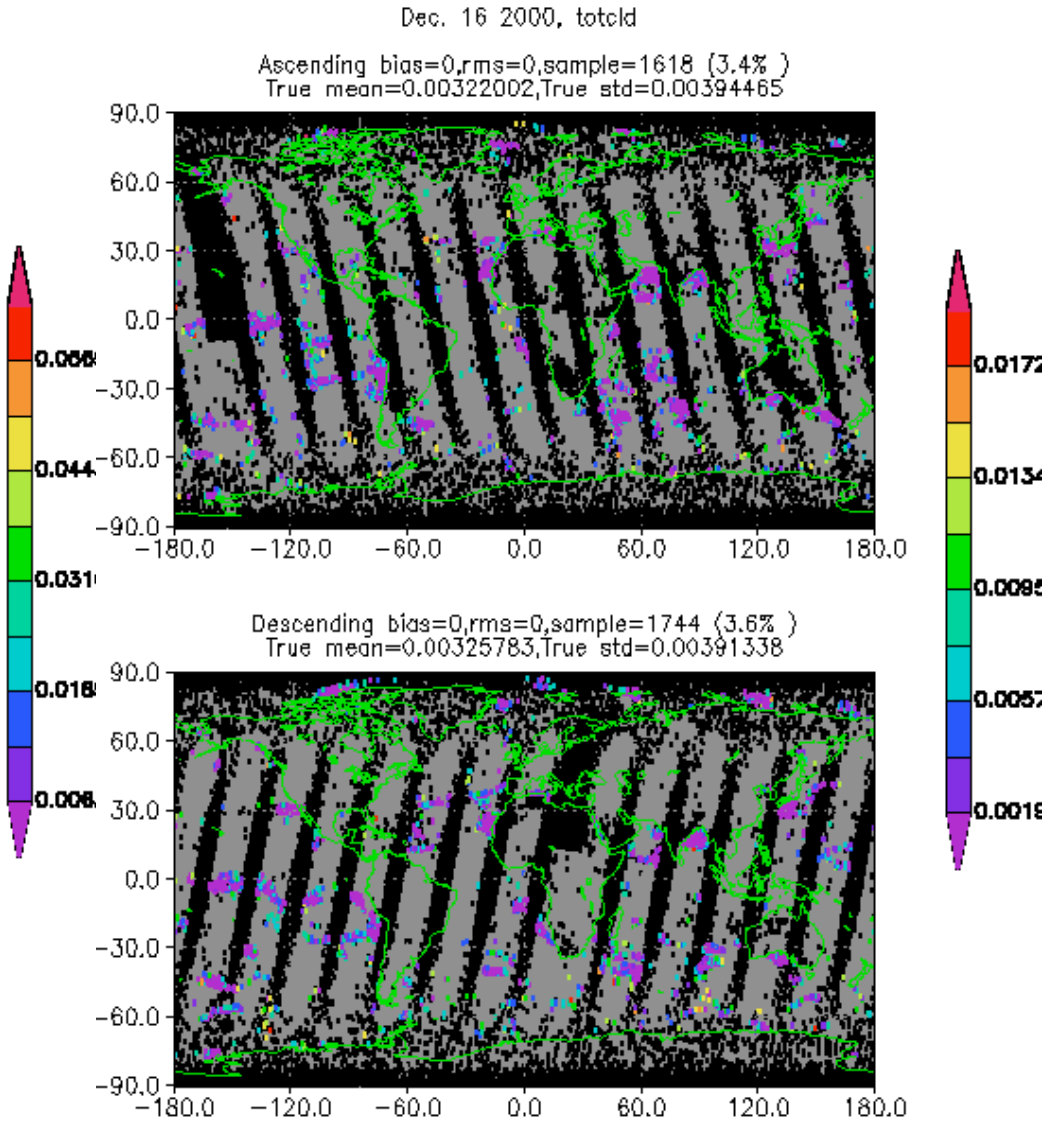

Predicted SST - Predicted SST < 0.1 K
N = 1503
BIAS 'clear simulation - obs'
RMS
5.5%
(.005, .008)
(K)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
750
1000
1250
1500
1750
2000
2250
2500
2750
Wavenumber (cm-1)

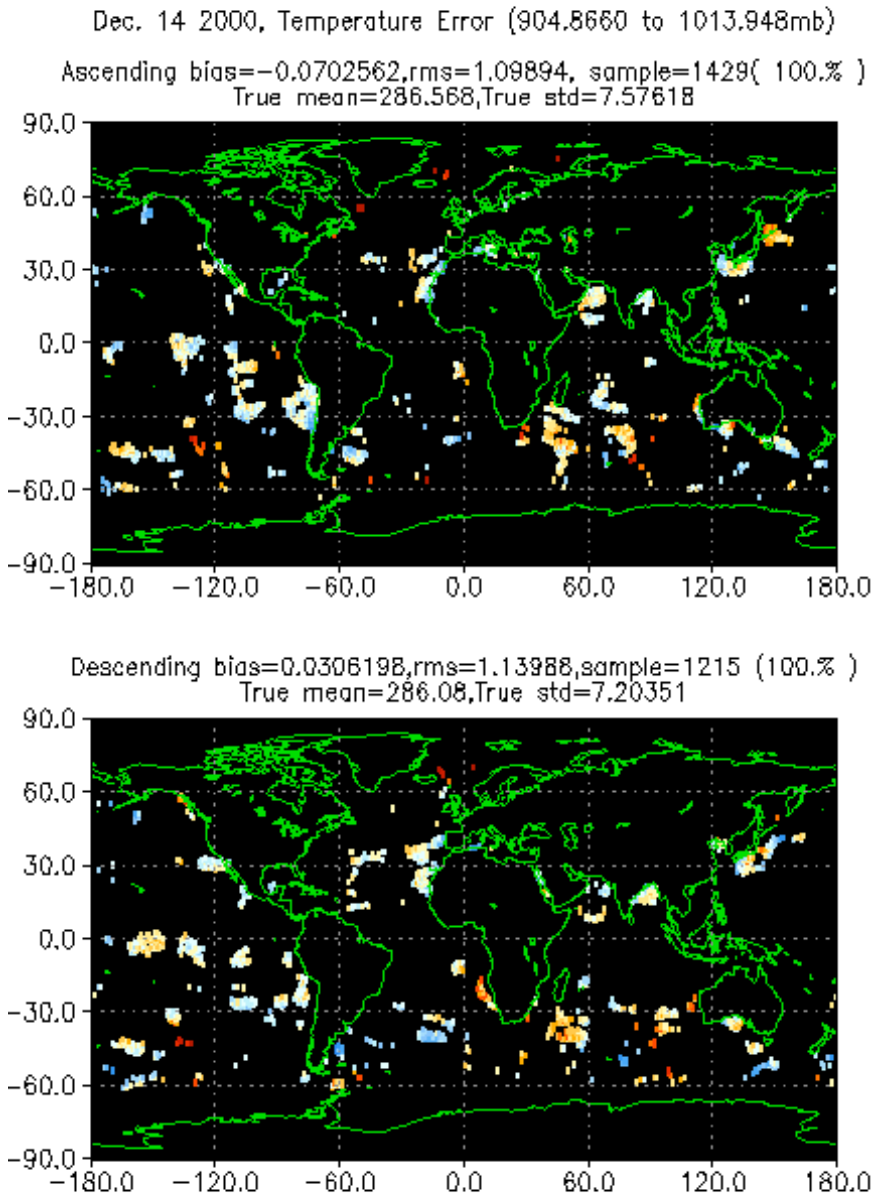
Day 1 Strategy

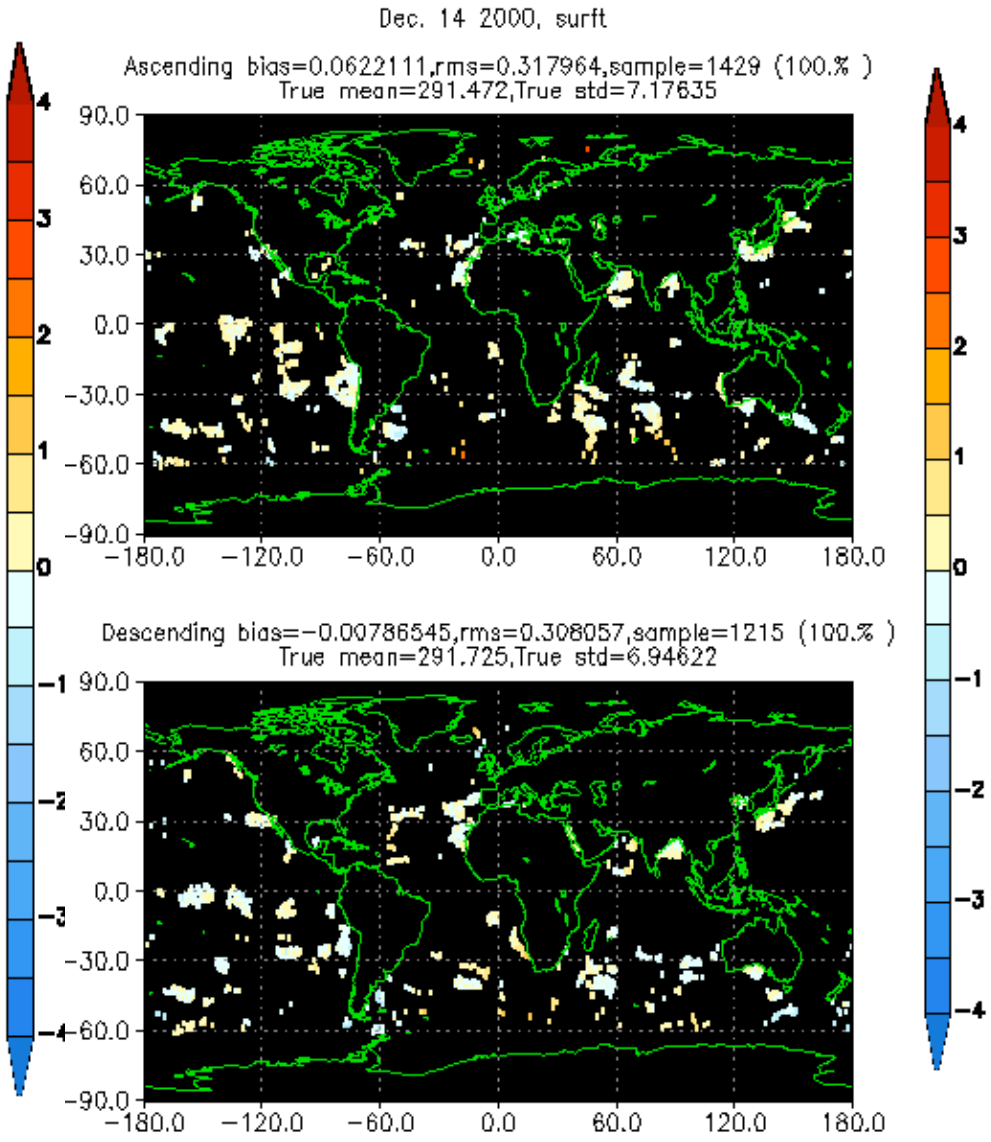
- Use 2616 vs SST to find night clear cases.
- Generate coefficients to predict SST from small set (4) 11 and 8 micron channels.
- Generate retrieval regression coefficients for ocean clear cases.
- Test retrieval algorithm for clear ocean data.

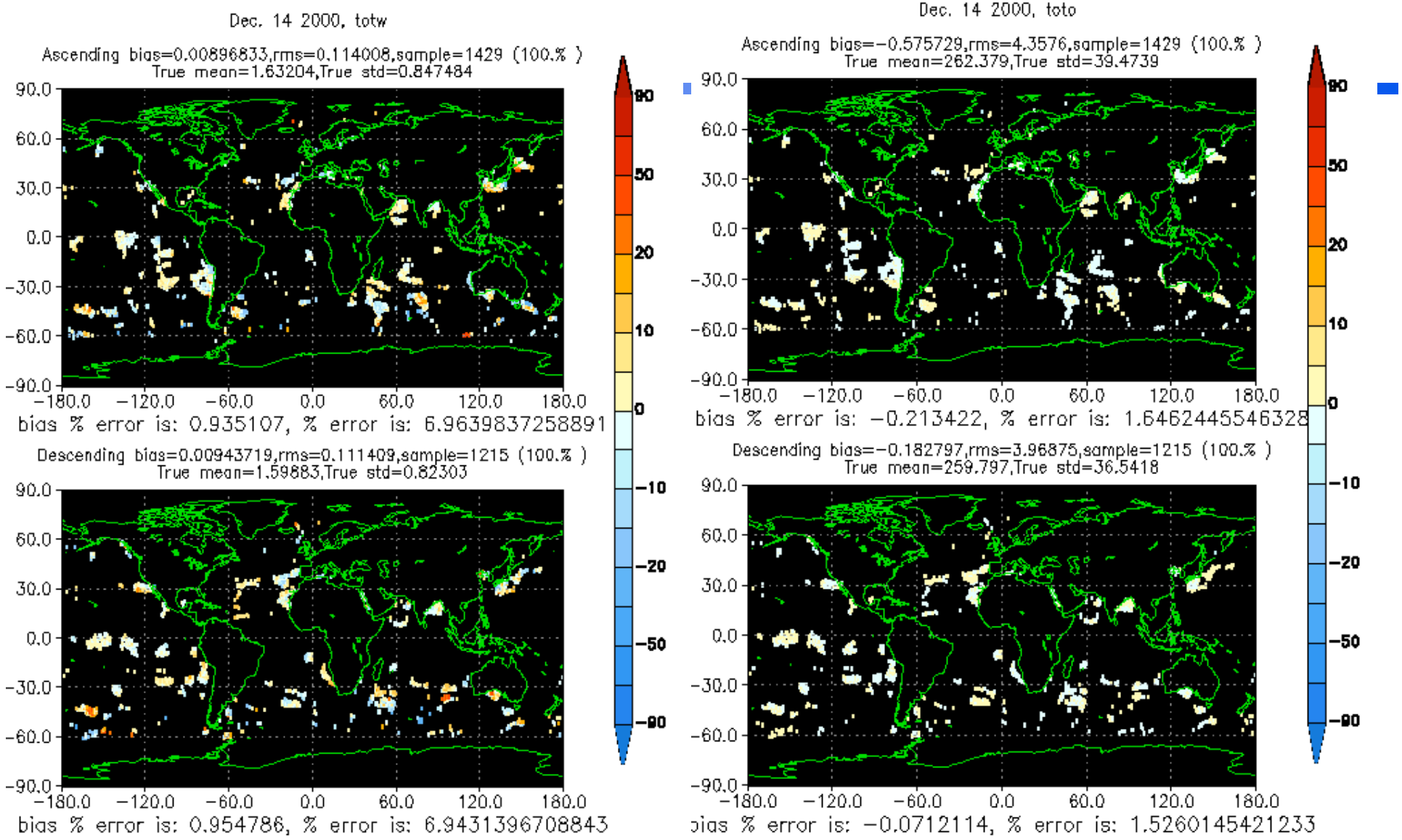
Detected Clear FOVS via predicting SST

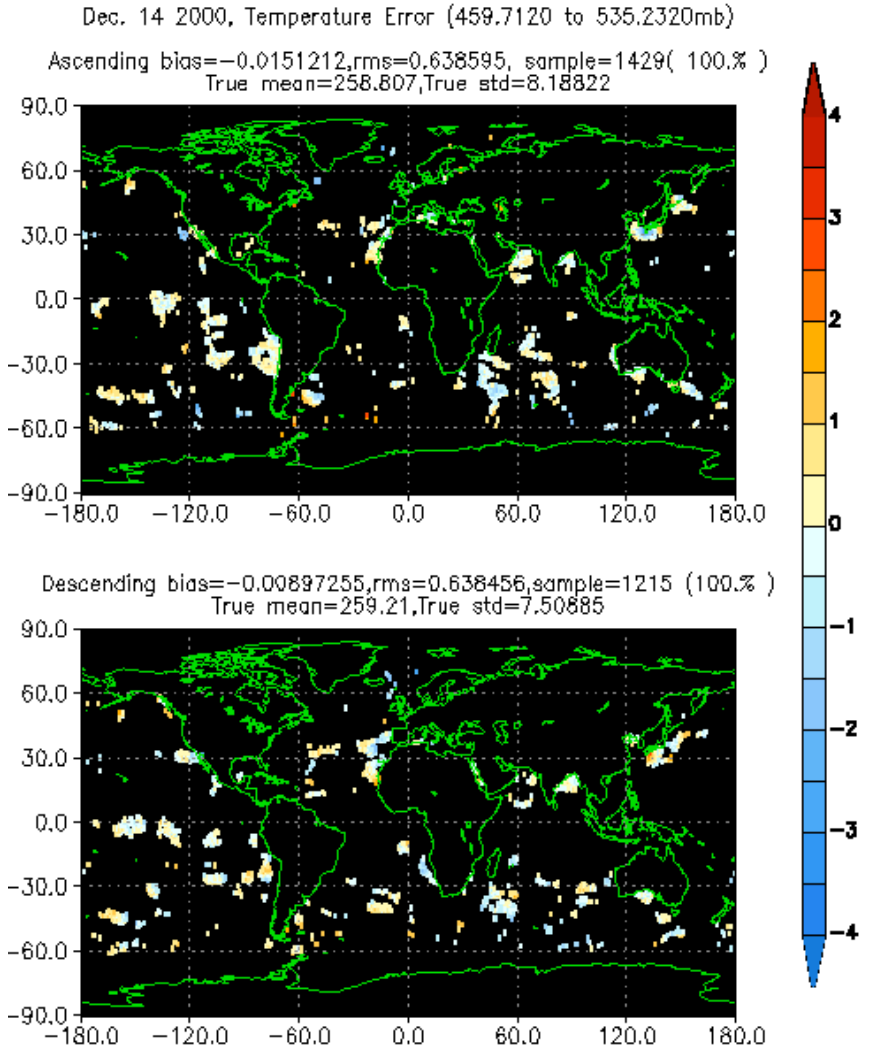


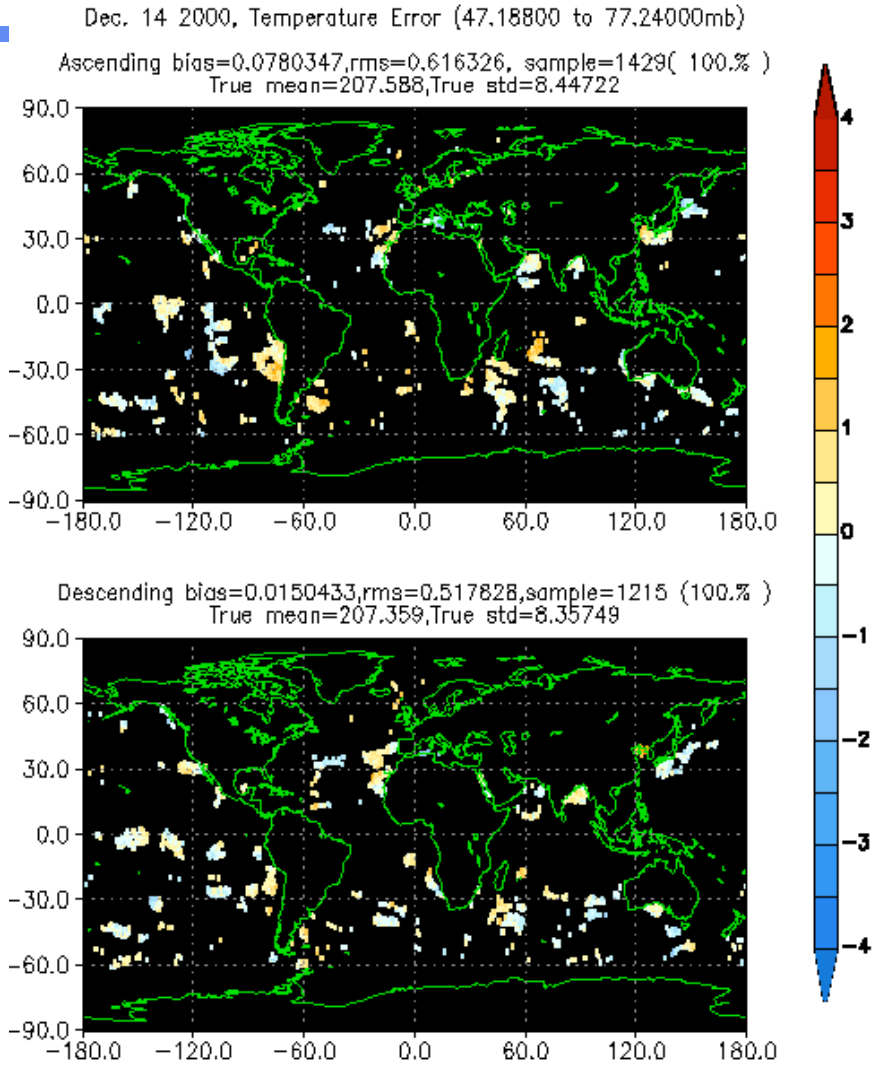


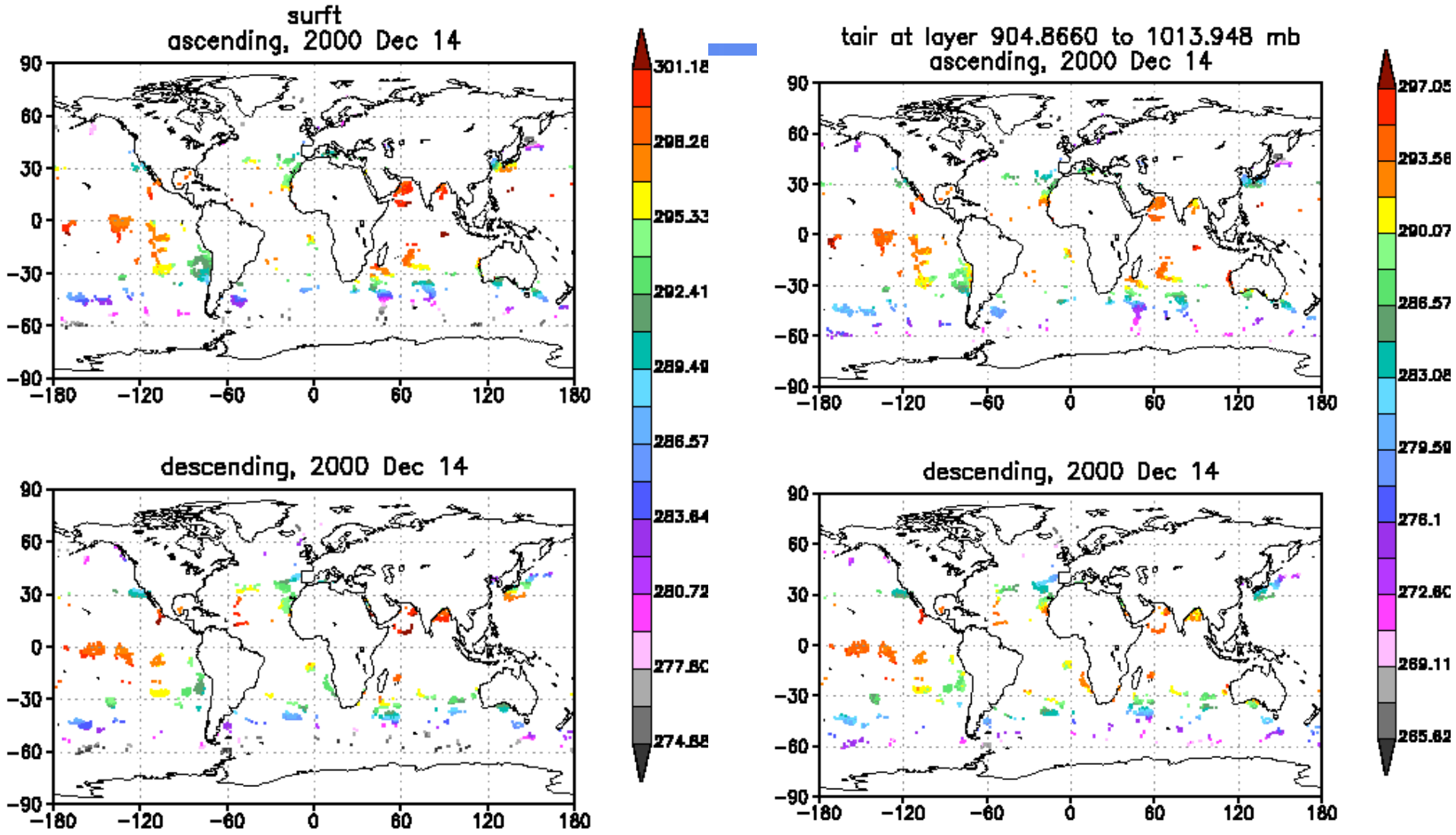

Dec. 14 2000, Temperature Error (904.8660 to 1013.948mb)
Ascending bias=-0.0702562,rms=1.09894, sample=1429(100.%)
True mean=286.568,True std=7.57618
Descending bias=0.0306198,rms=1.13988,sample=1215 (100.%)
True mean=286.08,True std=7.20351
90.0
60.0
30.0
0.0
-30.0
-60.0
-90.0
-180.0
-120.0
-60.0
0.0
60.0
120.0
180.0


Dec. 14 2000, surft
Ascending bias=0.0622111,rms=0.317964,sample=1429 (100.%)
True mean=291.472,True std=7.17635
Descending bias=-0.00786545,rms=0.308057,sample=1215 (100.%)
True mean=291.725,True std=6.94622
4
3
2
1
0
-1
-2
-3
-4
90.0
60.0
30.0
0.0
-30.0
-60.0
-90.0
-180.0
-120.0
-60.0
0.0
60.0
120.0
180.0

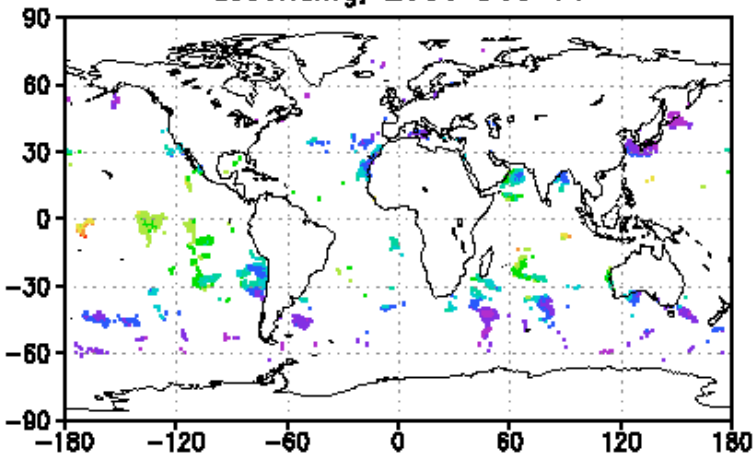

Dec. 14 2000, totw
Ascending bias=0.00896833,rms=0.114008,sample=1429 (100.%)
True mean=1.63204,True std=0.847484
bias % error is: 0.935107, % error is: 6.9639837258891
Descending bias=0.00943719,rms=0.111409,sample=1215 (100.%)
True mean=1.59883,True std=0.82303
bias % error is: 0.954786, % error is: 6.9431396708843
Dec. 14 2000, toto
Ascending bias=-0.575729,rms=4.3576,sample=1429 (100.%)
True mean=262.379,True std=39.4739
bias % error is: -0.213422, % error is: 1.6462445546328
Descending bias=-0.182797,rms=3.96875,sample=1215 (100.%)
True mean=259.797,True std=36.5418
bias % error is: -0.0712114, % error is: 1.5260145421233
90.0
60.0
30.0
0.0
-30.0
-60.0
-90.0
-180.0
-120.0
-60.0
0.0
60.0
120.0
180.0
90
50
20
10
0
-10
-20
-50
-90


Dec. 14 2000, Temperature Error (459.7120 to 535.2320mb)
Ascending bias=−0.0151212,rms=0.638595, sample=1429(100.%)
True mean=258.807,True std=8.18822
Descending bias=−0.00897255,rms=0.638456,sample=1215 (100.%)
True mean=259.21,True std=7.50885
90.0
60.0
30.0
0.0
-30.0
-60.0
-90.0
−180.0
−120.0
−60.0
0.0
60.0
120.0
180.0
4
3
2
1
0
−1
−2
−3
−4

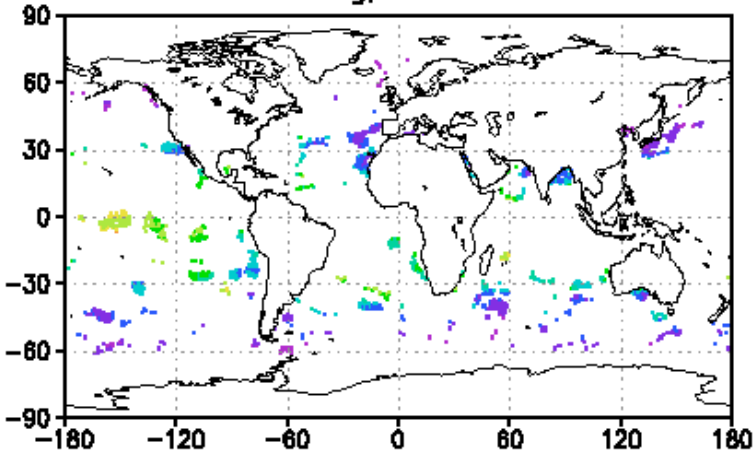

Dec. 14 2000, Temperature Error (47.18800 to 77.24000mb)
Ascending bias=0.0780347,rms=0.616326, sample=1429(100.%)
True mean=207.588,True std=8.44722
Descending bias=0.0150433,rms=0.517828,sample=1215 (100.%)
True mean=207.359,True std=8.35749
90.0
60.0
30.0
0.0
-30.0
-60.0
-90.0
−180.0
−120.0
−60.0
0.0
60.0
120.0
180.0
4
3
2
1
0
−1
−2
−3
−4

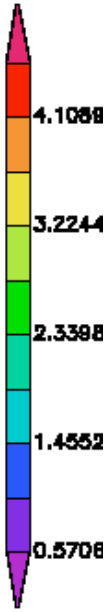

surft
ascending, 2000 Dec 14
descending, 2000 Dec 14
tair at layer 904.8660 to 1013.948 mb
ascending, 2000 Dec 14
descending, 2000 Dec 14
90
60
30
0
-30
-60
-90
-180
-120
-60
0
60
120
180
301.18
298.26
295.33
292.41
289.49
286.57
283.64
280.72
277.80
274.88
297.05
293.56
290.07
286.57
283.08
279.59
276.1
272.60
269.11
265.62

totw
ascending, 2000 Dec 14

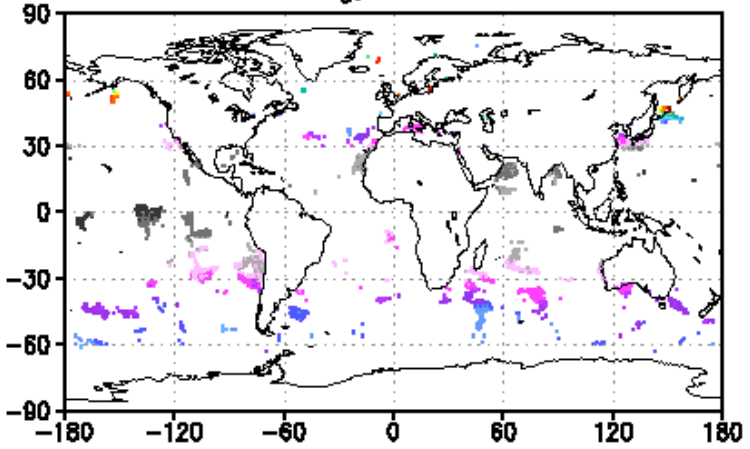


descending, 2000 Dec 14

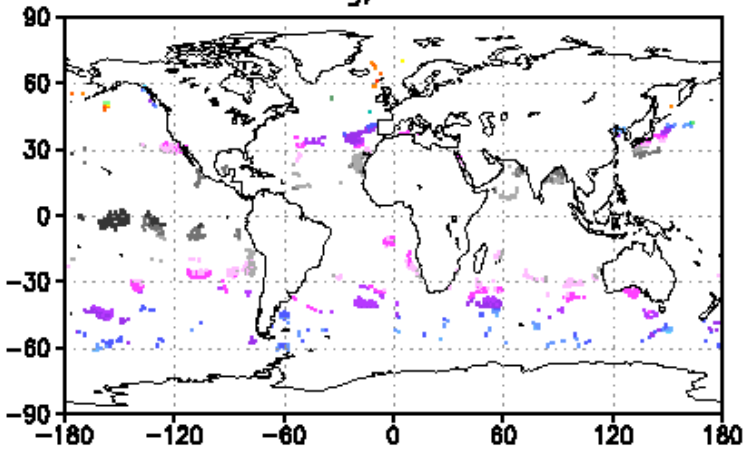


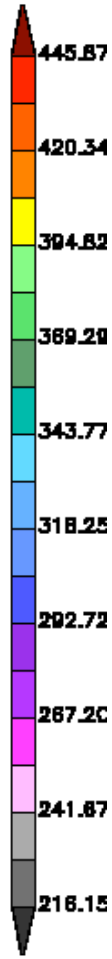


tota
ascending, 2000 Dec 14



descending, 2000 Dec 14





Conclusion

- Use of SST from NCEP analysis is important.
- Start out using SST – 2616 channels (night).
- Use cumulative distribution function of SST- predicted SST to determine threshold.
- For Day 1 - Generate regression coefficients for ocean clear.
- Test retrieval algorithm on ocean clear data before tackling other situations.
- Day 2: test partial overcast over sea to test cloud clearing.
- Experiment with MODIS.