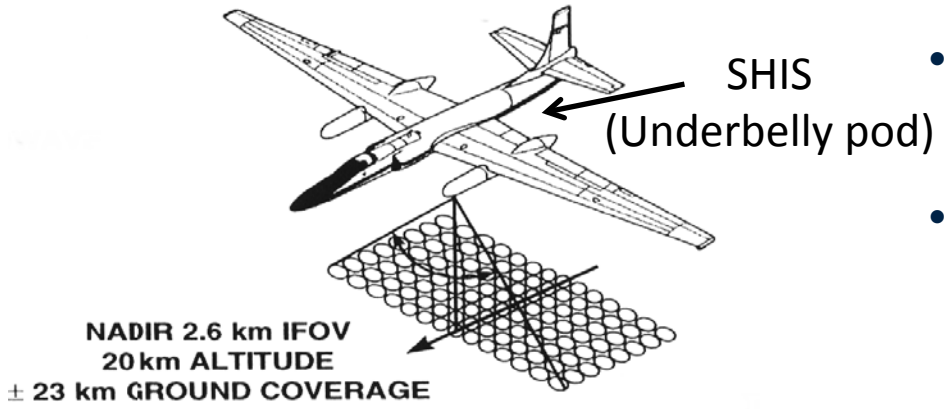
Validation of CrIS Dual Regression Sounding Products during the Airborne Suomi-NPP Cal/Val Campaign

W. L. Smith Sr., A. M. Larar, H. E. Revercomb, M. Yesalusky, E. Weisz, M. Goldberg

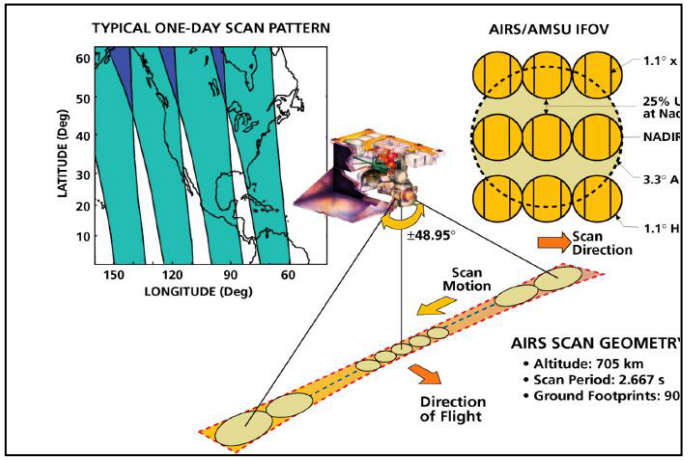
The ER-2 Aircraft Interferometers

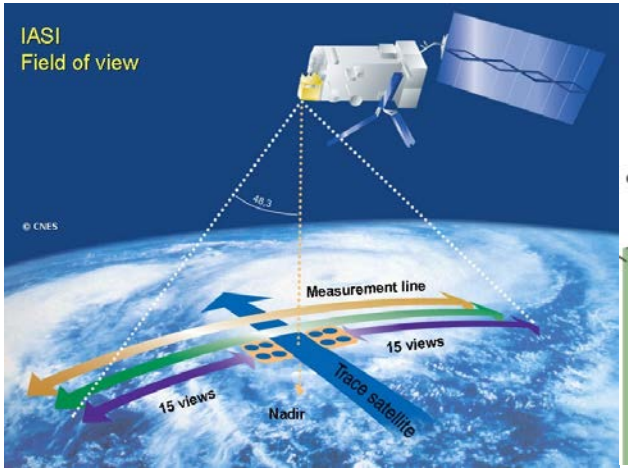


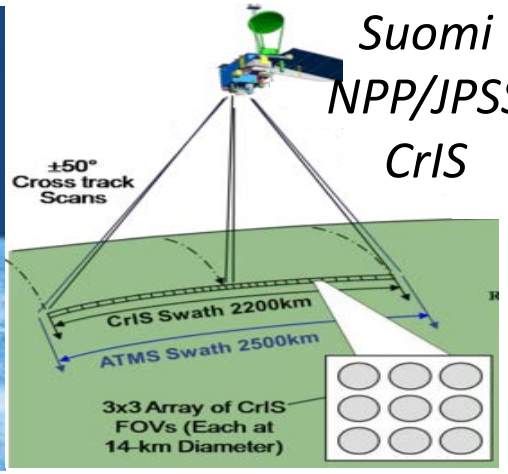
- **NAST-I/SHIS-I** infrared Michelson interferometer
  (9000/4500 spectral channels)
  3.5 – 16 microns @ 0.25 /0.5cm^{-1}
- **Aircraft Accommodation**
  - NAST-I: ER-2 Super pod
  - SHIS: ER-2 Underbelly pod

Instrument	Spatial resolution	Spectral Resolution	Useful Spectral Range	Spatial Sampling
NAST-I	2.6 Km @ 20 Km	0.25 (cm^{-1})	600-2800 (cm^{-1})	~ Contiguous Cross-track scan
SHIS	2.0 Km @ 20 Km	0.50 (cm^{-1})	600-2800 (cm^{-1})	~ Contiguous Cross-track Scan

The Satellite Instruments

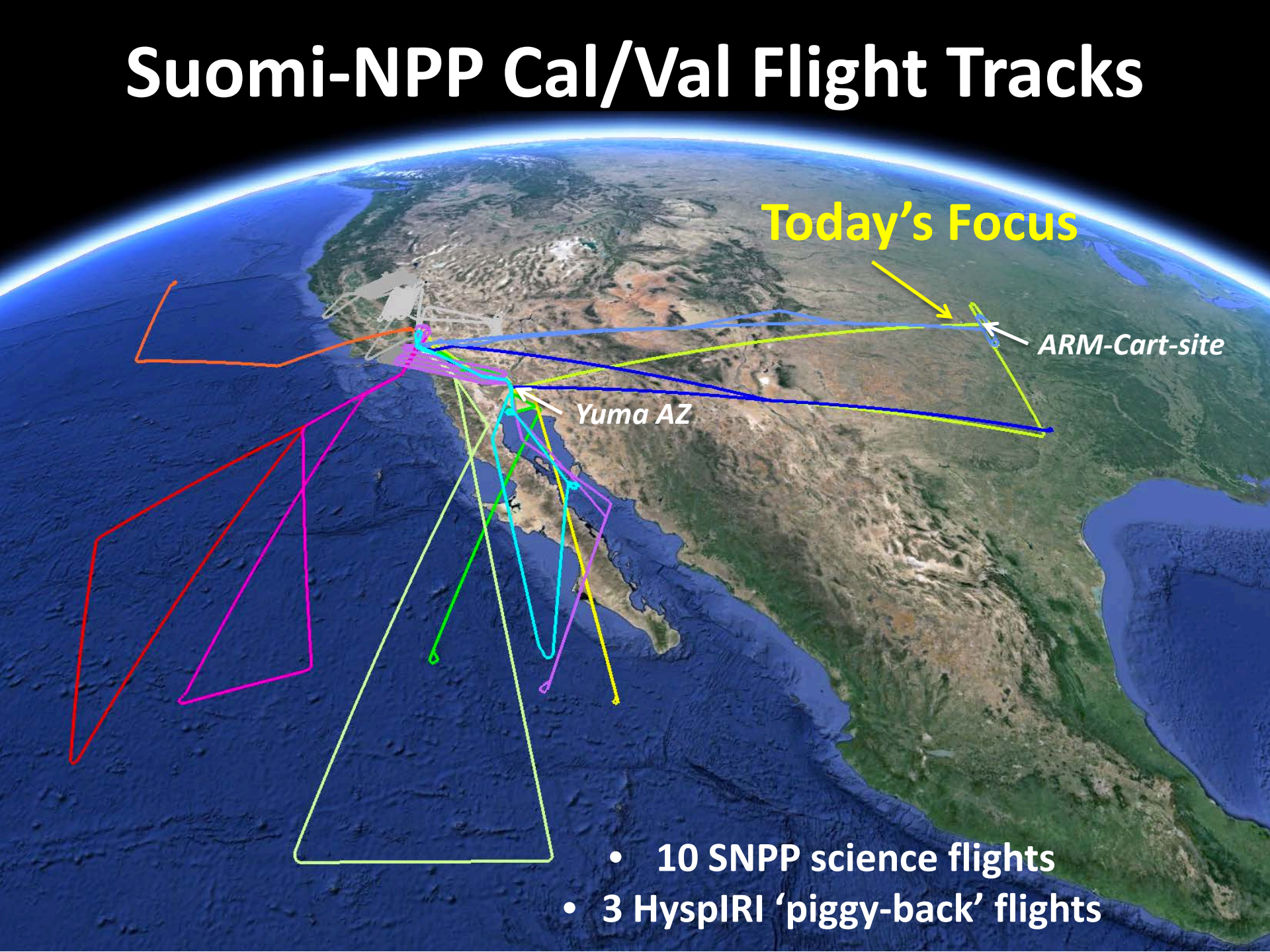






Instrument	Spatial resolution	spectral res. (cm^{-1})	spectral rng. (cm^{-1})	spatial sampling
AIRS (2002 -)	3x3 13.5-km (50 km)	~1200 resolving power	645-2700	Contiguous Cross-track scan
IASI-A (2006 -) IASI-B (2012 -)	2x2 12.0-km (50 km)	0.25	645-2760	Contiguous Cross-track Scan
CrIS (2011 -)	3 x 3 13-km (50 km)	0.6	645-2700	Contiguous Cross-track

Suomi-NPP Cal/Val Flight Tracks



The Dual Regression Retrieval Algorithm

Global Clear Soundings

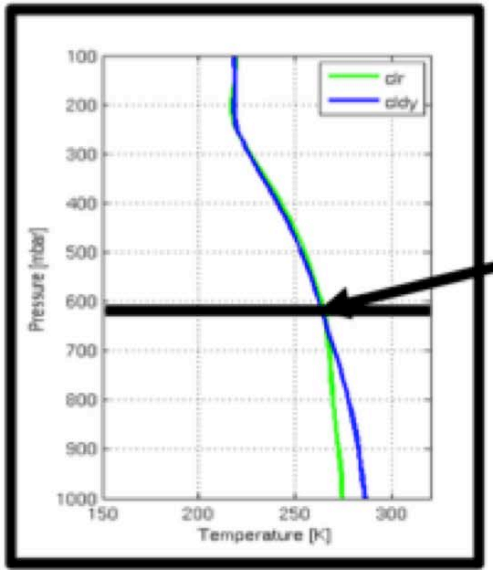
Global Cloudy Soundings

Radiances (calculated with clear FM)

Radiances (calculated with cloudy FM) 8 cloud height classes (100-900 hPa)

Clear trained EOF regression results

Cloud trained EOF regression results



Cloud Top Altitude

level where T(cloudy)>T(clear) for $p>p_{cld}$

Final Profile

•clear-trained above,

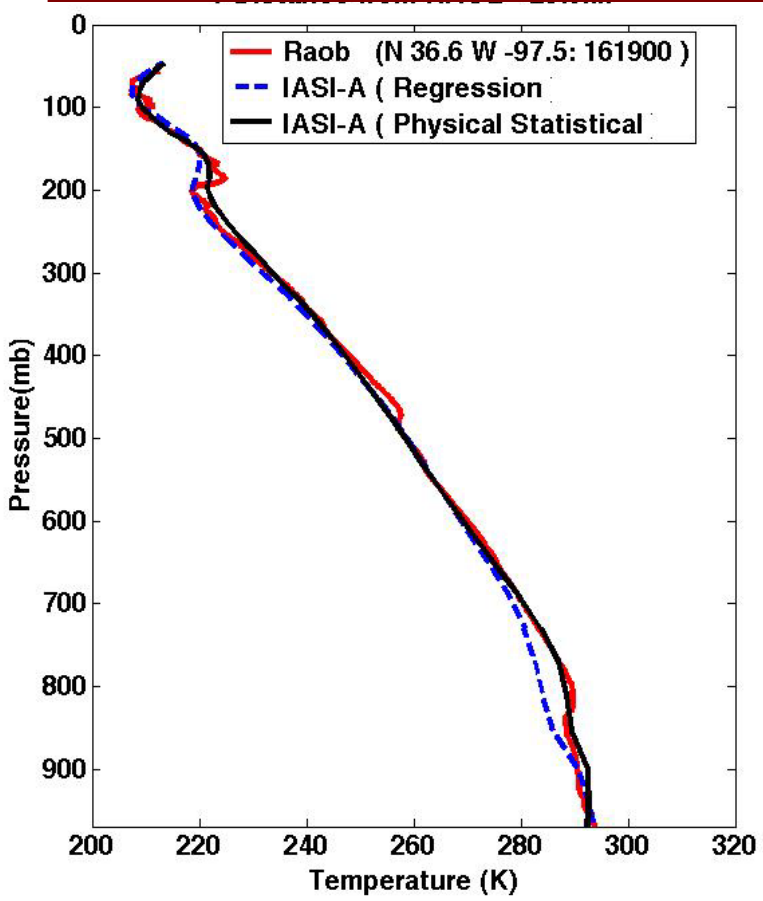
•cloud-trained below cloud level

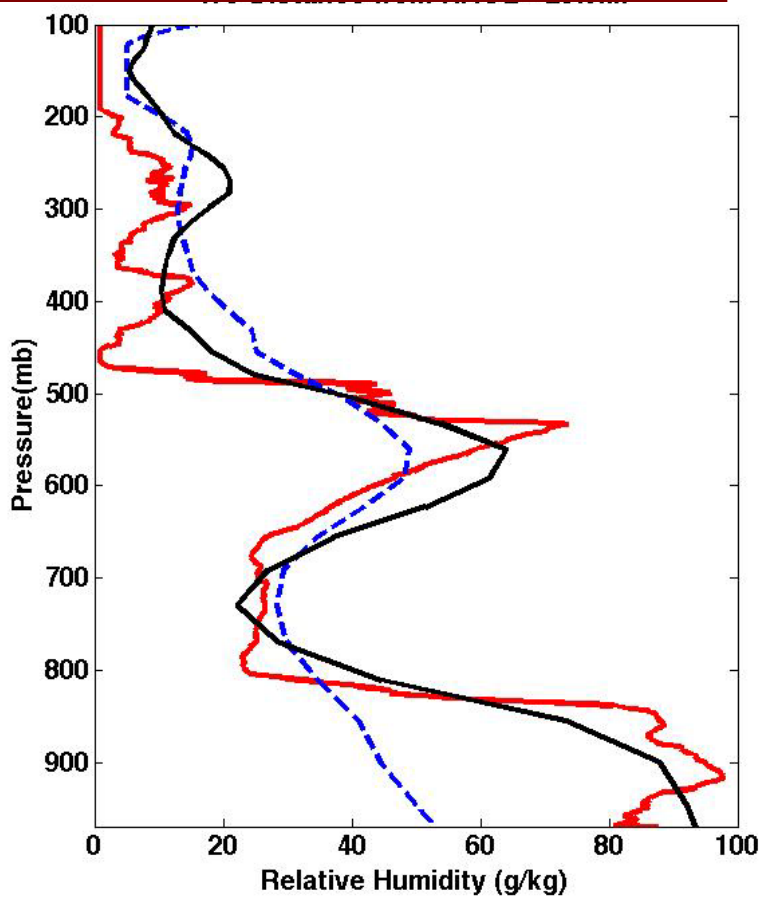
Physical Correction Using Forecast Model Profile

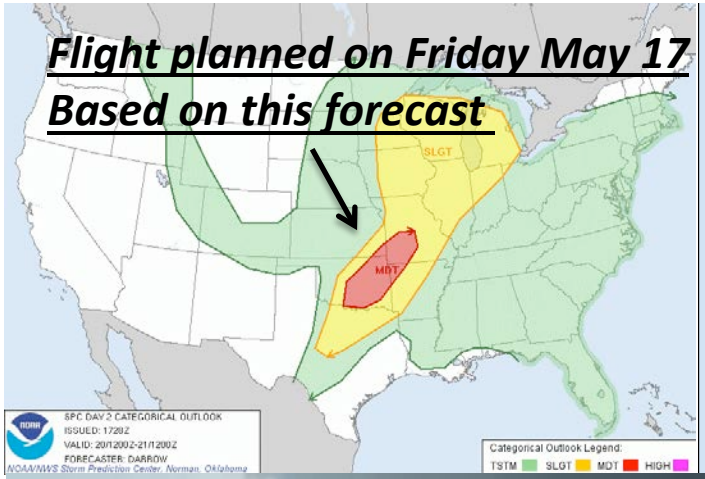
Problem: DR method uses a statistical training data set. Imperfect skill, due to lack of vertical resolution in radiances, leads to local statistical bias.

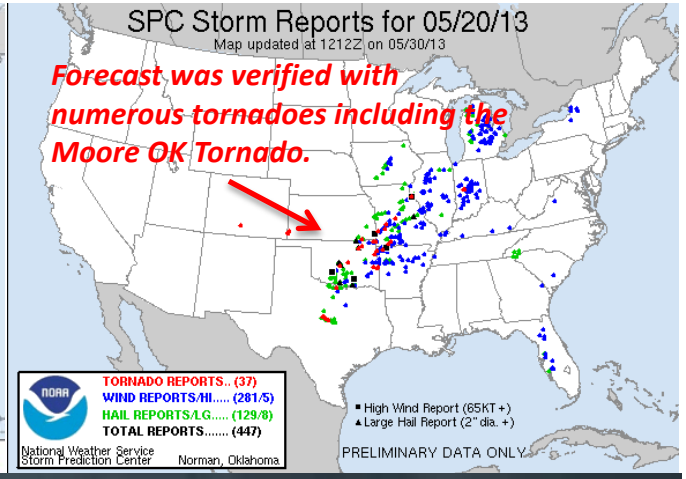
Solution: Calculate radiances from forecast profile (FP) and perform DR retrieval using simulated radiances. Retrieval Error = Physical Correction.

Physical Correction= FP – FP radiance Retrieval



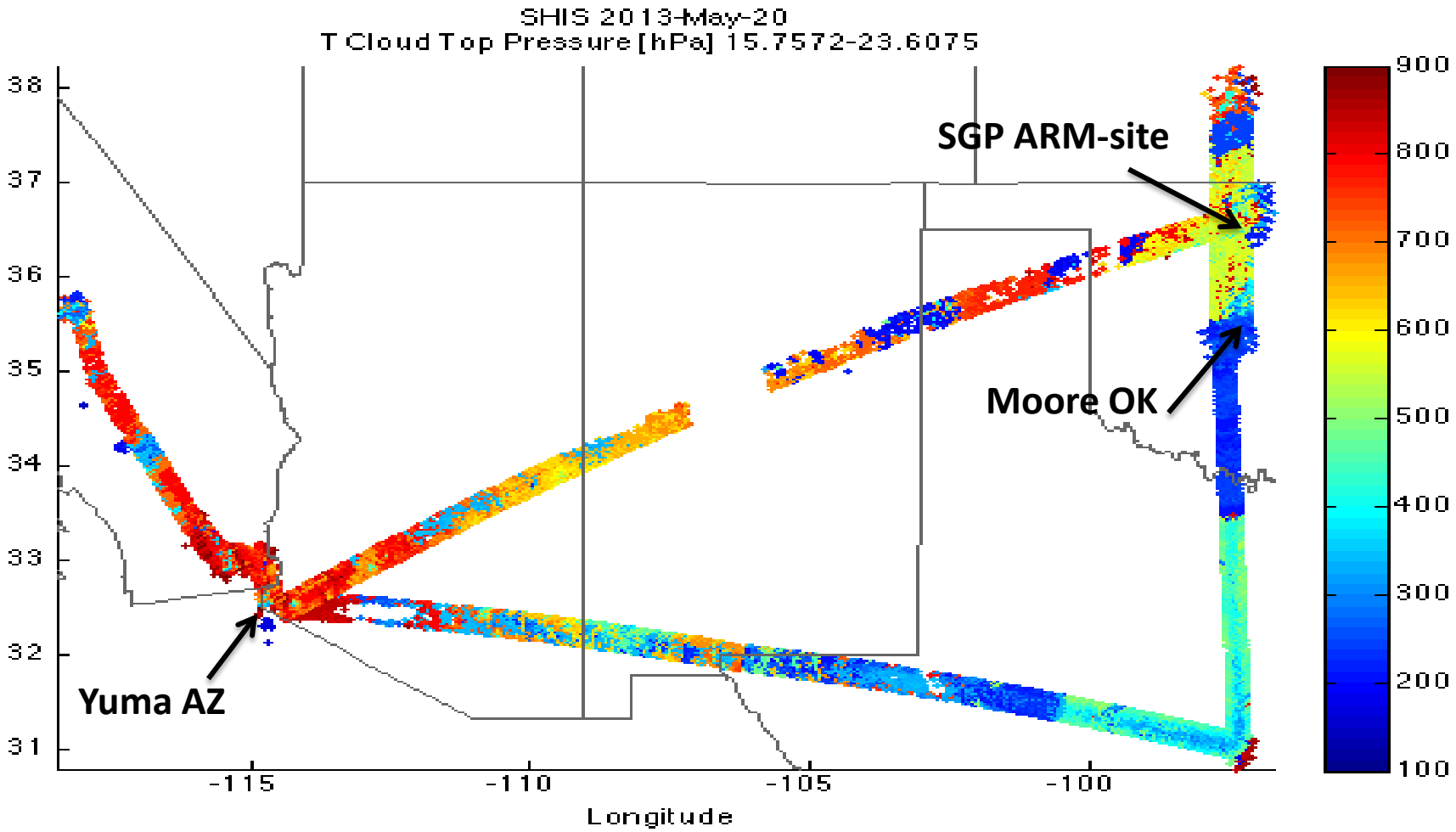




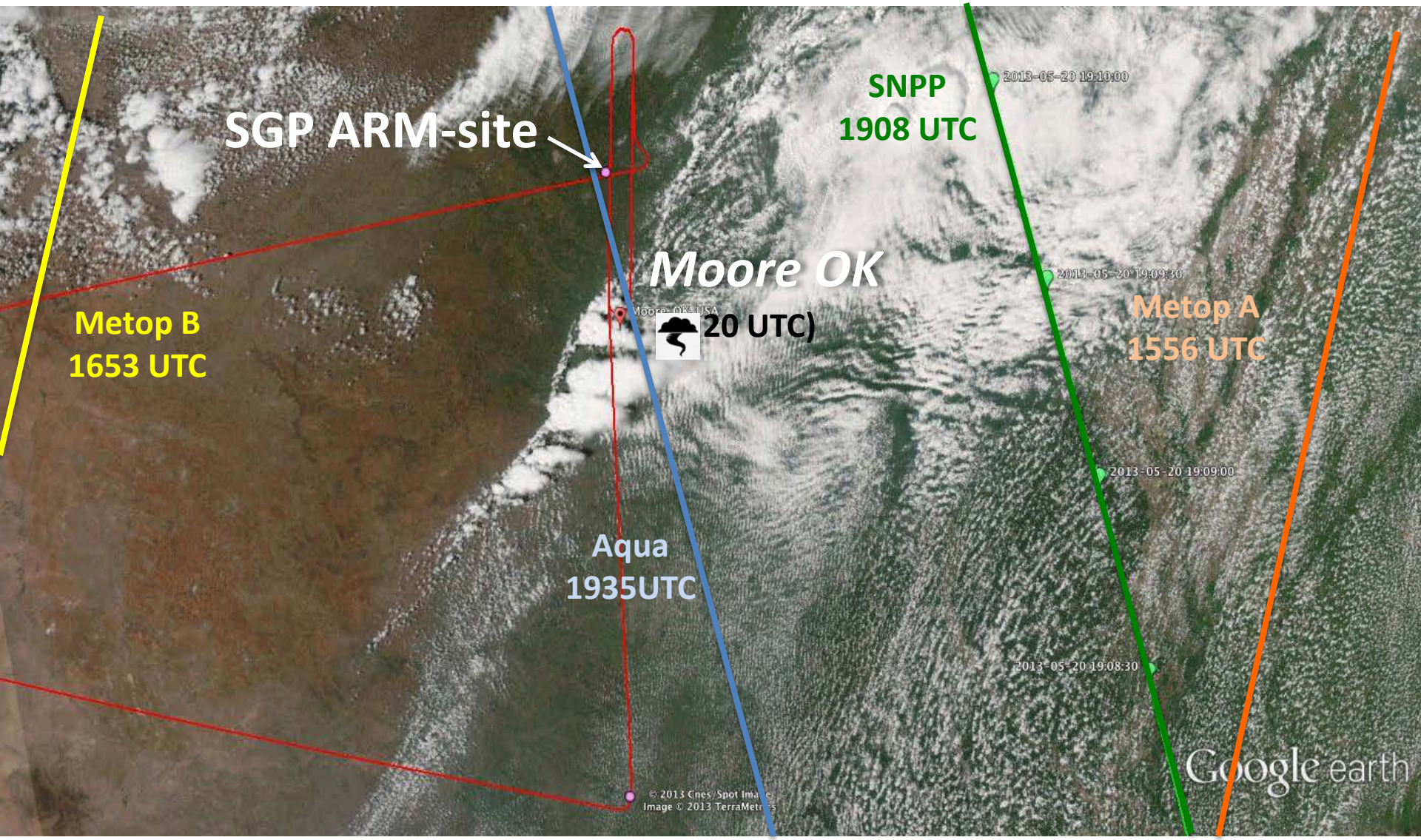


*The **2013 Moore tornado** was an EF5 Tornado that struck Moore, Oklahoma, and adjacent areas on the afternoon of May 20, 2013, with peak winds estimated at 210 miles per hour (340 km/h), killing 23 people (+2 indirectly) and injuring 377 others. The tornado touched down west of Moore at 2:56 PM CDT (19:56 UTC), staying on the ground for 39 minutes over a 17-mile (27 km) path, crossing through a heavily populated section of Moore. The tornado was 1.3 miles (2.1 km) wide at its peak.*

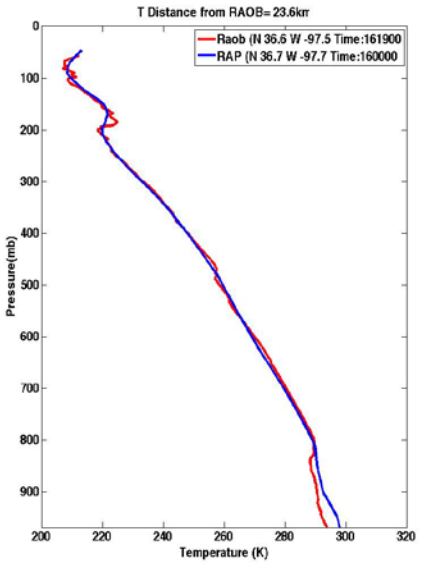
ER-2 Flight Track
Cloud Pressure Altitude

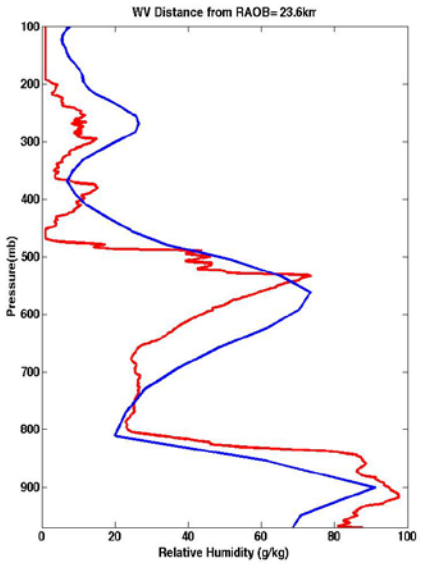


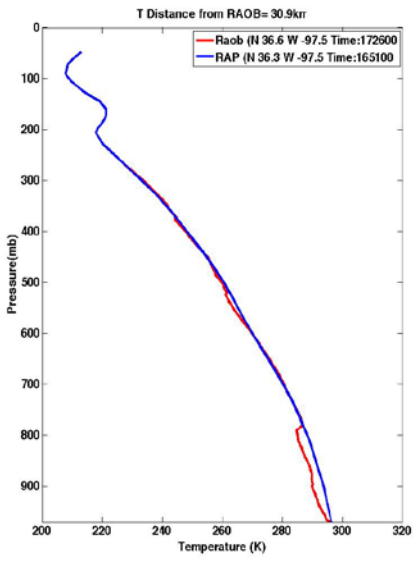
Aircraft Track and Satellite Orbits

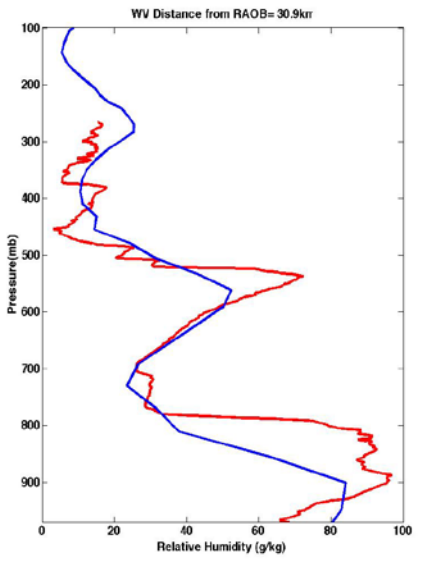


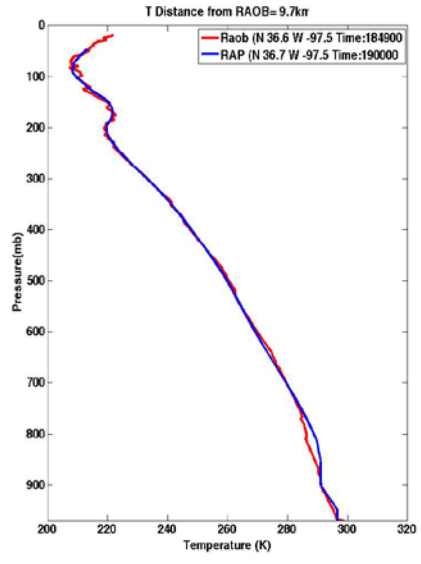
RAP Model Profiles Vs ARM-site Radiosondes

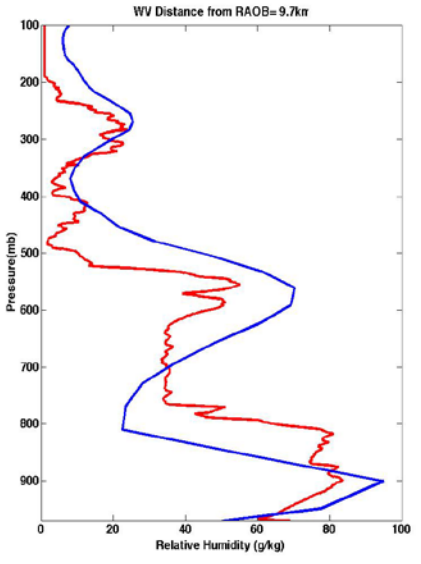


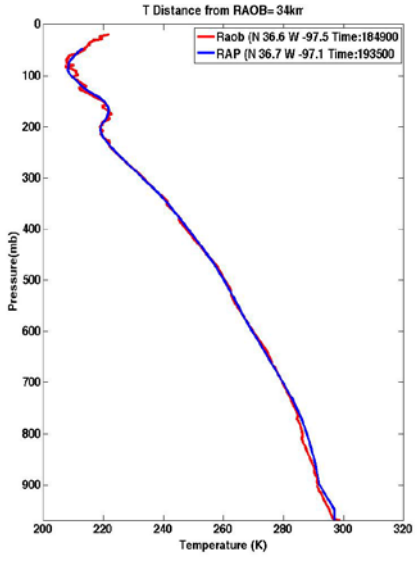


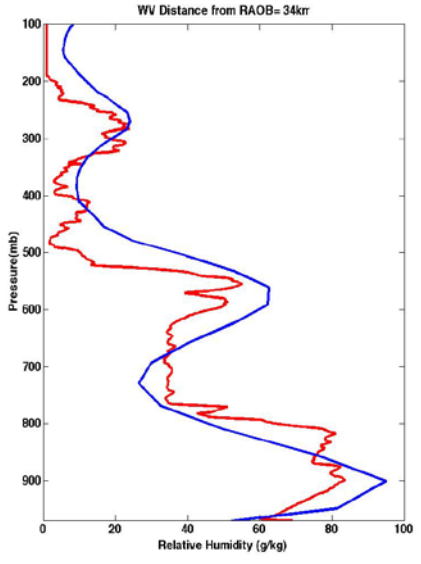




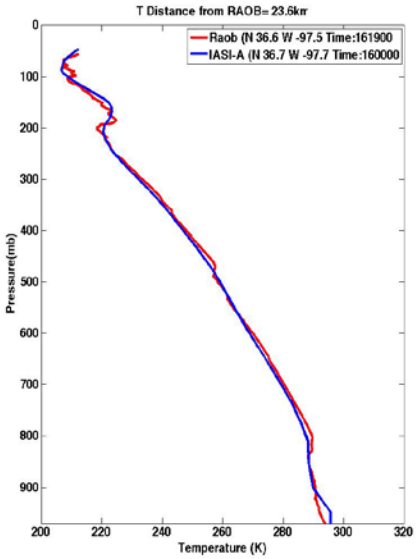


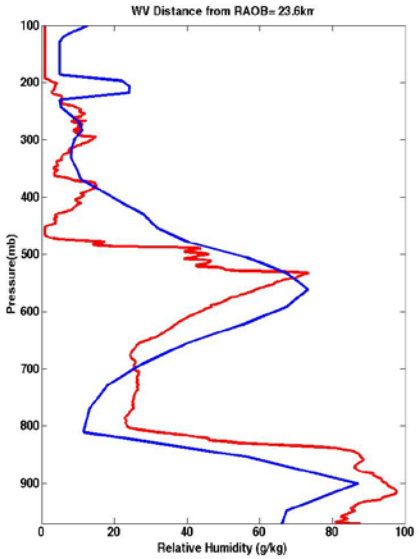


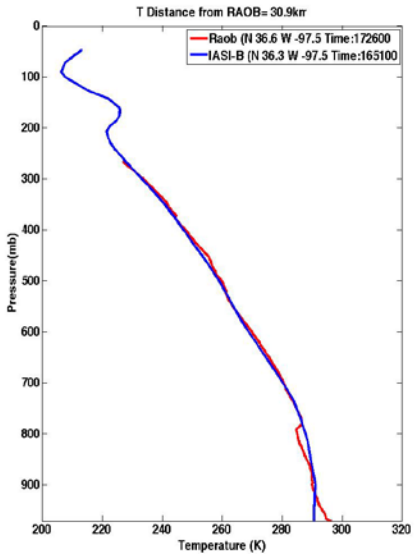


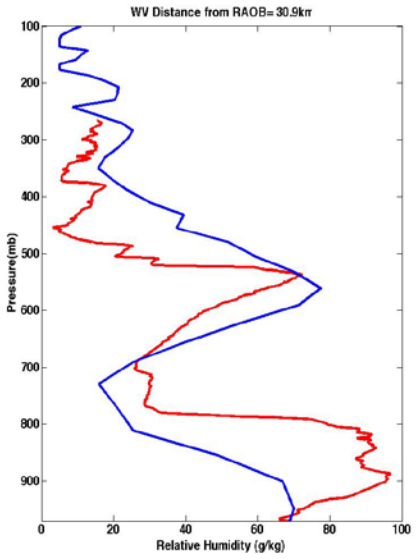


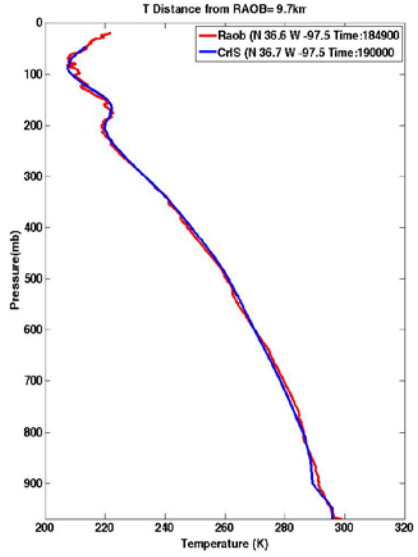
Satellite Retrievals Vs ARM-site Radiosondes

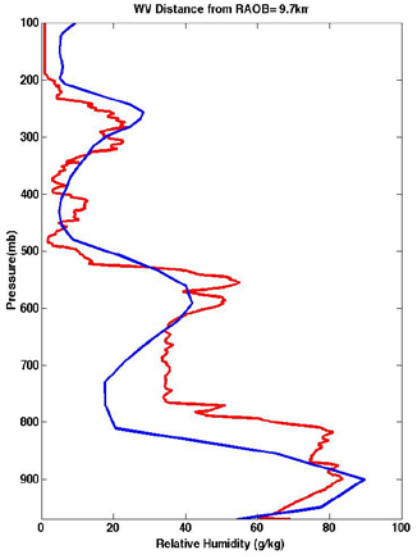


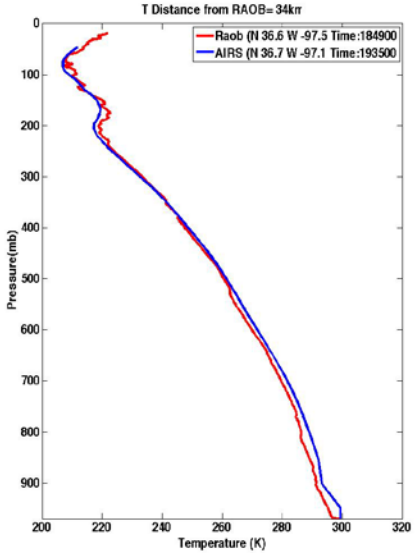


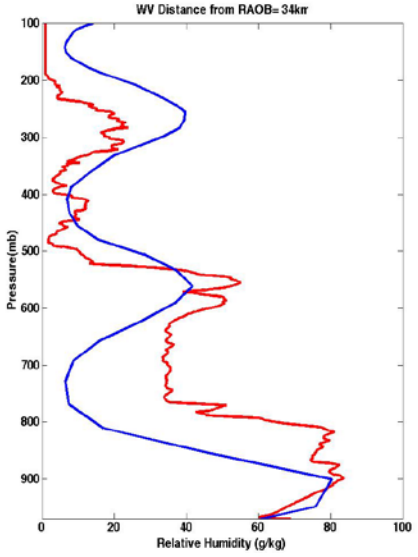












Lifted Index Stability Parameter

The **lifted index** (**LI**) is the temperature difference between an air parcel lifted adiabatically T(p) and the temperature of the environment Te(p) at a pressure height in the troposphere of 500 hPa (mb). When the value is positive, the atmosphere (at the respective height) is stable and when the value is negative, the atmosphere is unstable.

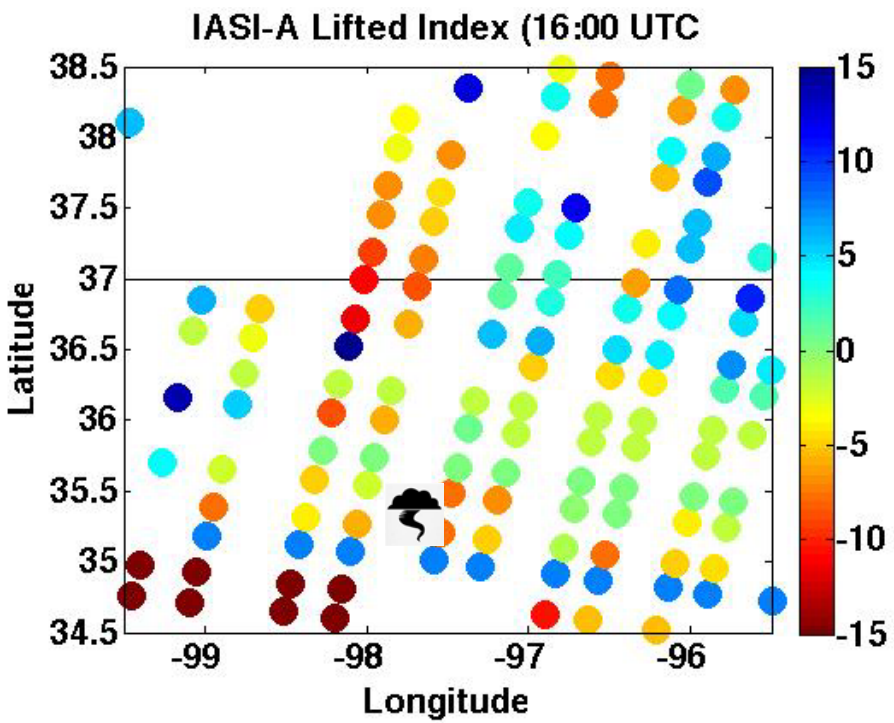
Thunderstorm Potential:

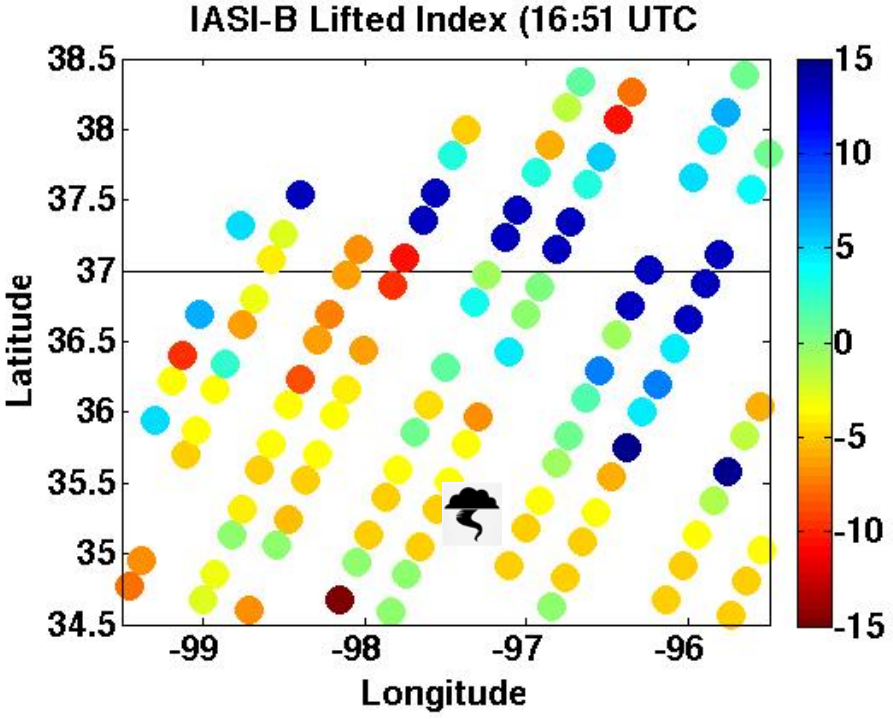
< -5 Very Unstable: Strong Thunderstorm Potential

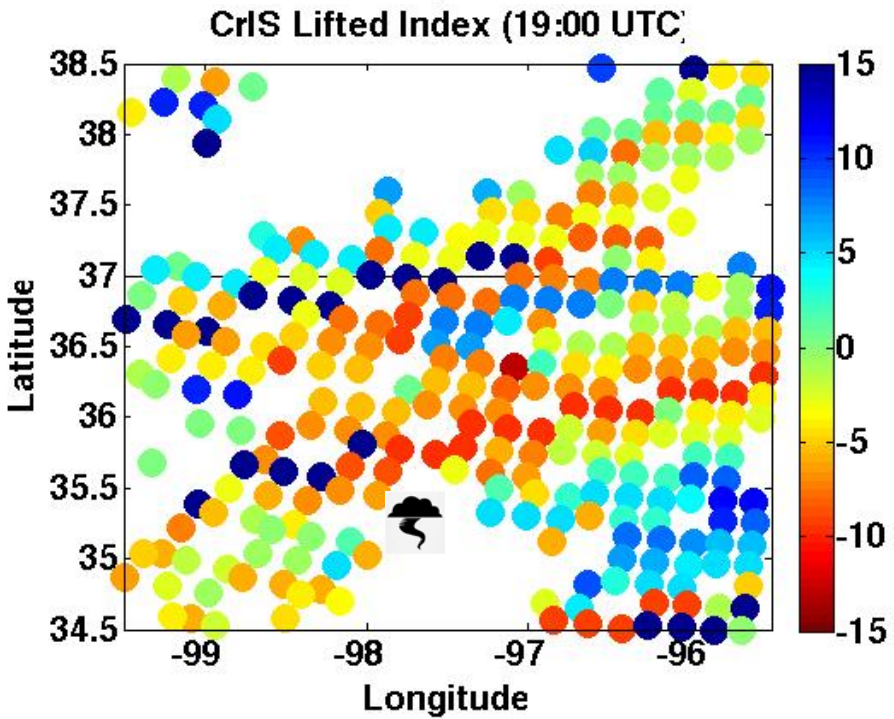
-3 to -5 Unstable: Thunderstorm Probable

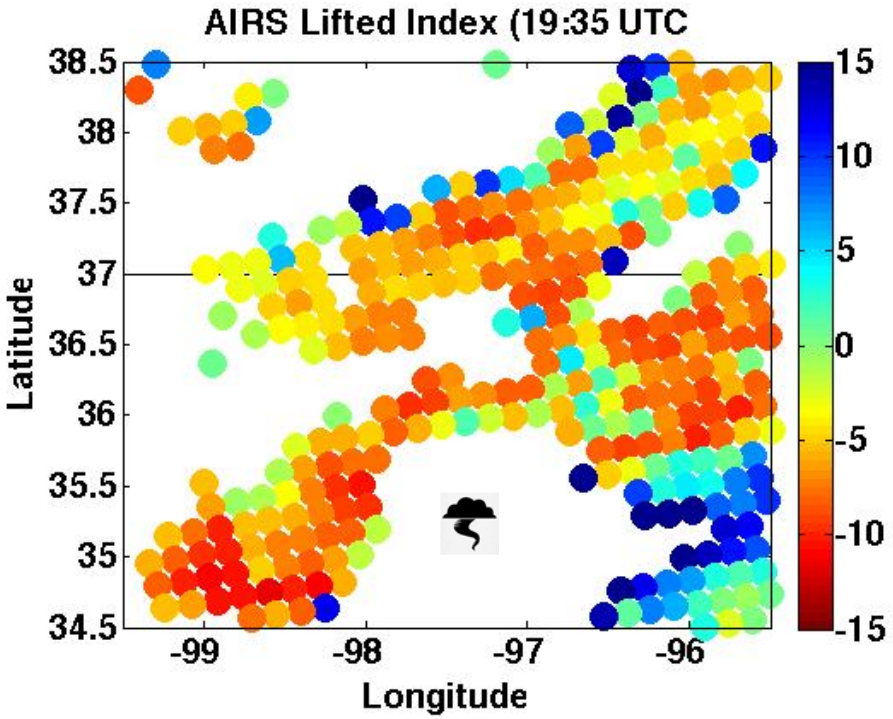
0 to -2 Marginally Unstable: Thunderstorms Possible

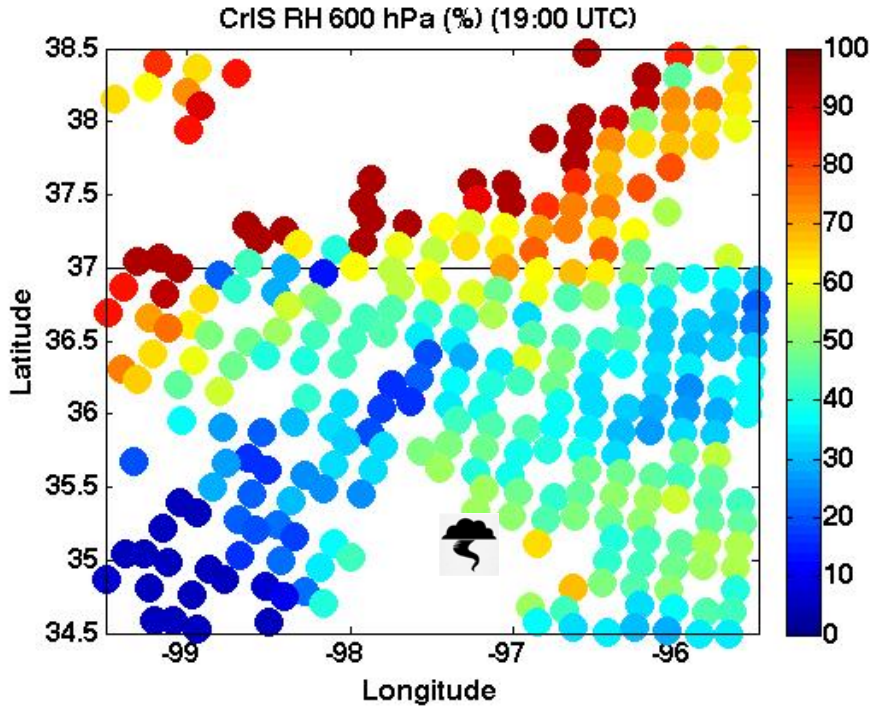
>0: Stable: Thunderstorms Unlikely

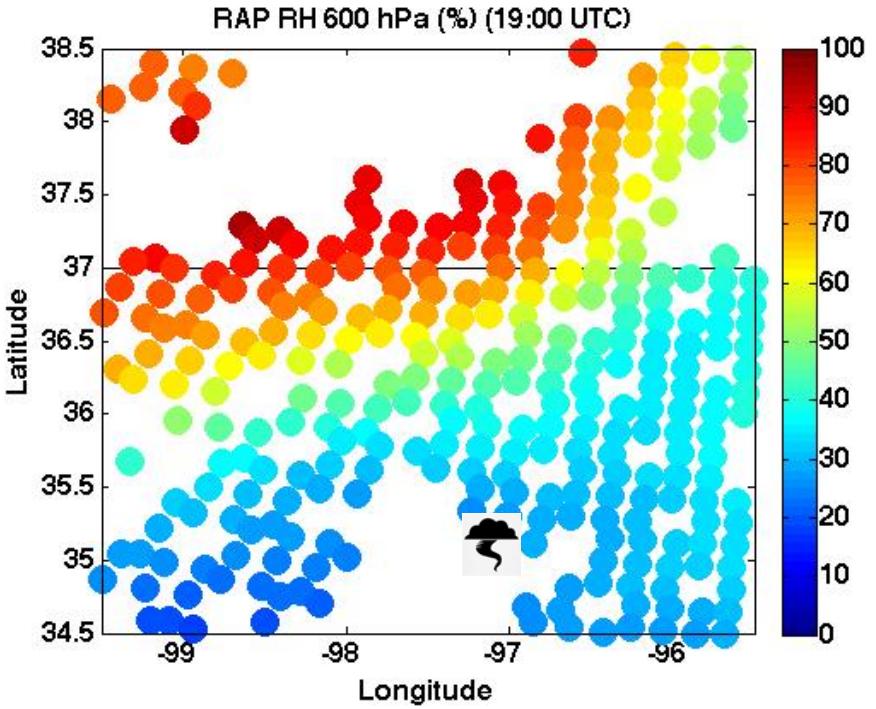

IASI-A Lifted Index (16:00 UTC
Latitude
Longitude
38.5
38
37.5
37
36.5
36
35.5
35
34.5
-99
-98
-97
-96
15
10
5
0
-5
-10
-15

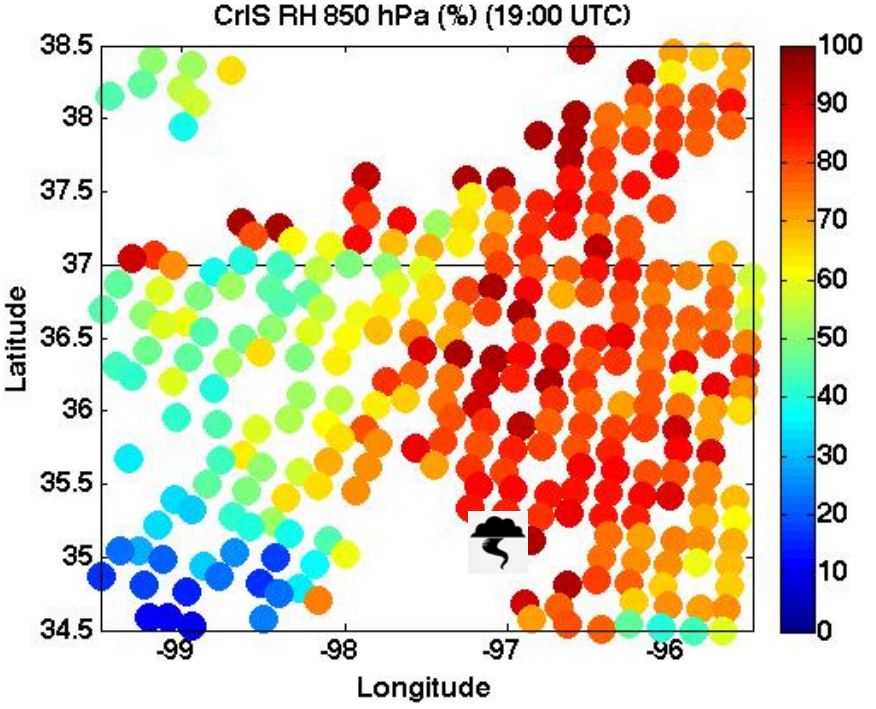

IASI-B Lifted Index (16:51 UTC
Latitude
Longitude
38.5
38
37.5
37
36.5
36
35.5
35
34.5
-99
-98
-97
-96
15
10
5
0
-5
-10
-15

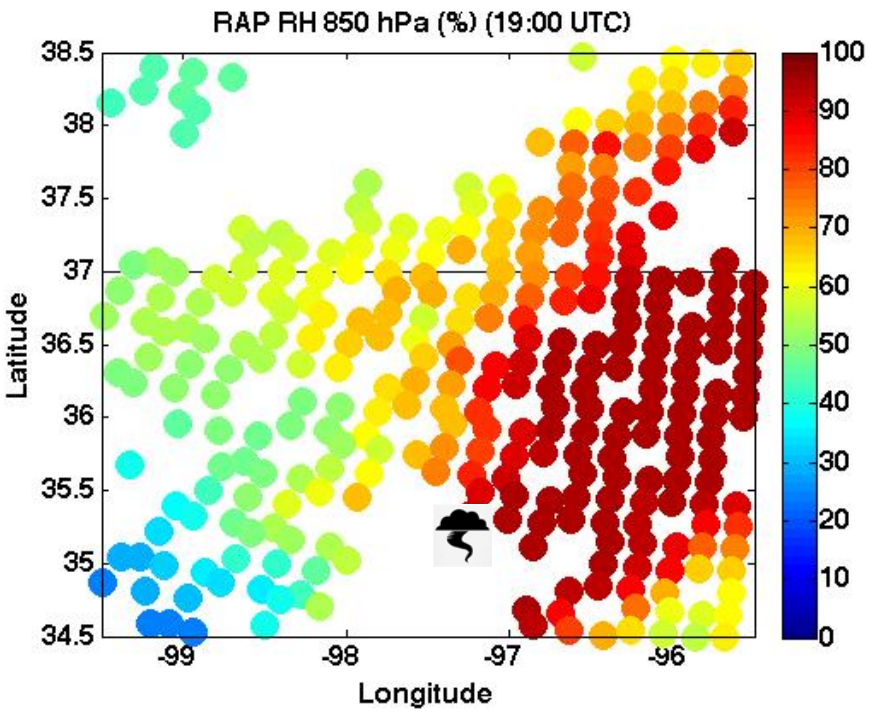

CrIS Lifted Index (19:00 UTC)
Latitude
Longitude
38.5
38
37.5
37
36.5
36
35.5
35
34.5
-99
-98
-97
-96
15
10
5
0
-5
-10
-15


AIRS Lifted Index (19:35 UTC
Latitude
Longitude
38.5
38
37.5
37
36.5
36
35.5
35
34.5
-99
-98
-97
-96
15
10
5
0
-5
-10
-15

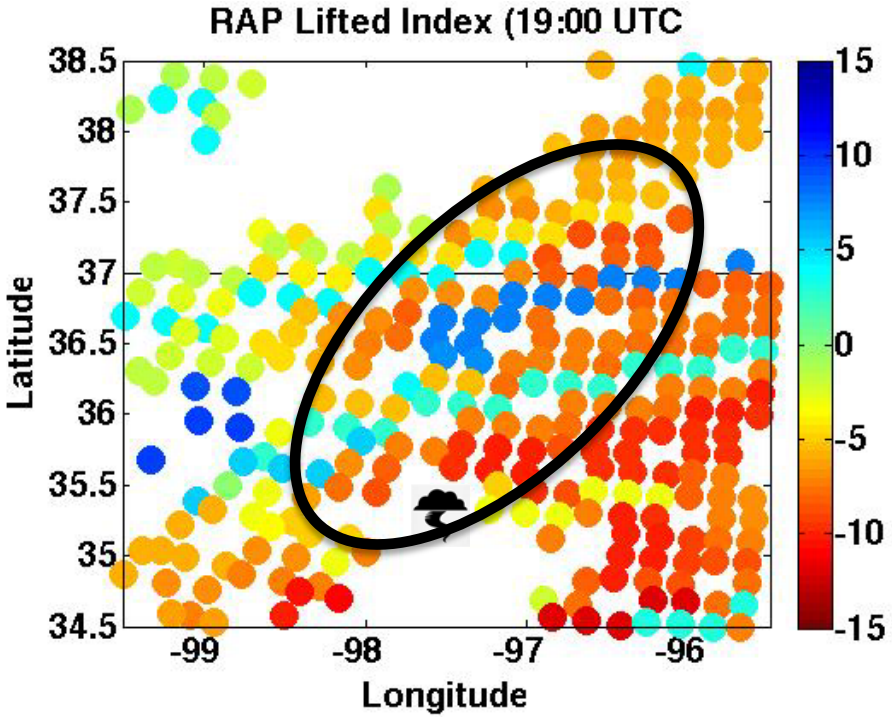

CrIS RH 600 hPa (%) (19:00 UTC)
Latitude
Longitude
38.5
38
37.5
37
36.5
36
35.5
35
34.5
-99
-98
-97
-96
100
90
80
70
60
50
40
30
20
10
0

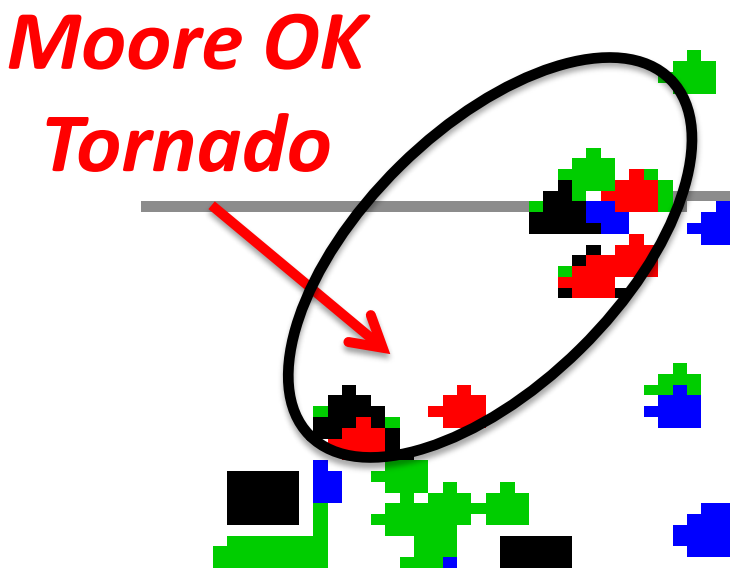

RAP RH 600 hPa (%) (19:00 UTC)
Latitude
Longitude
38.5
38
37.5
37
36.5
36
35.5
35
34.5
-99
-98
-97
-96
100
90
80
70
60
50
40
30
20
10
0


CrIS RH 850 hPa (%) (19:00 UTC)
Latitude
Longitude
38.5
38
37.5
37
36.5
36
35.5
35
34.5
-99
-98
-97
-96
100
90
80
70
60
50
40
30
20
10
0


RAP RH 850 hPa (%) (19:00 UTC)
Latitude
Longitude
38.5
38
37.5
37
36.5
36
35.5
35
34.5
-99
-98
-97
-96
100
90
80
70
60
50
40
30
20
10
0

RAP Model Instability Vs Tornado Reports





Thunderstorm Potential:

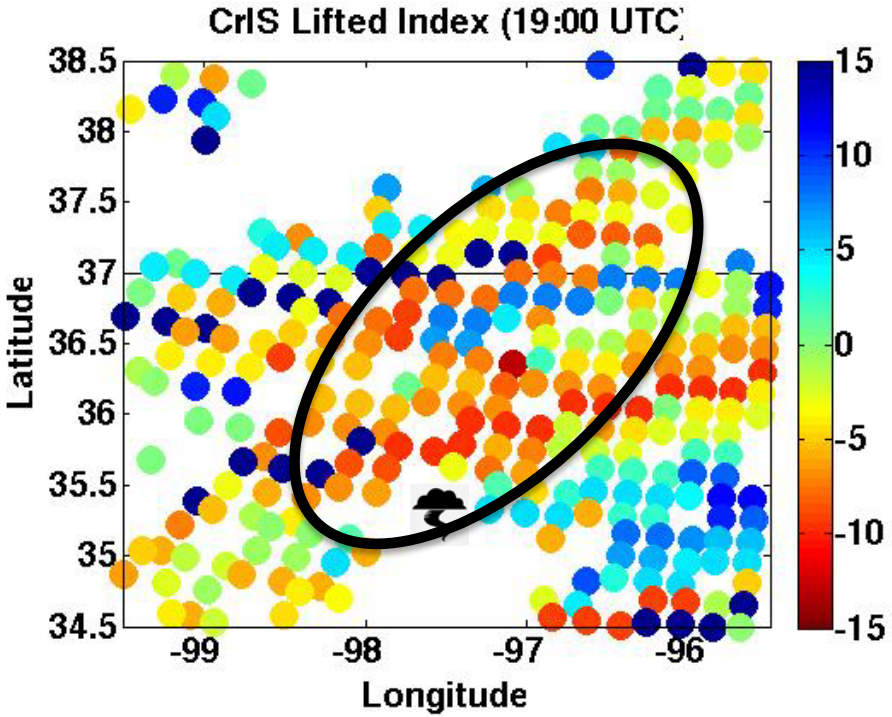
< -5 Very Unstable: Strong Thunderstorm Potential

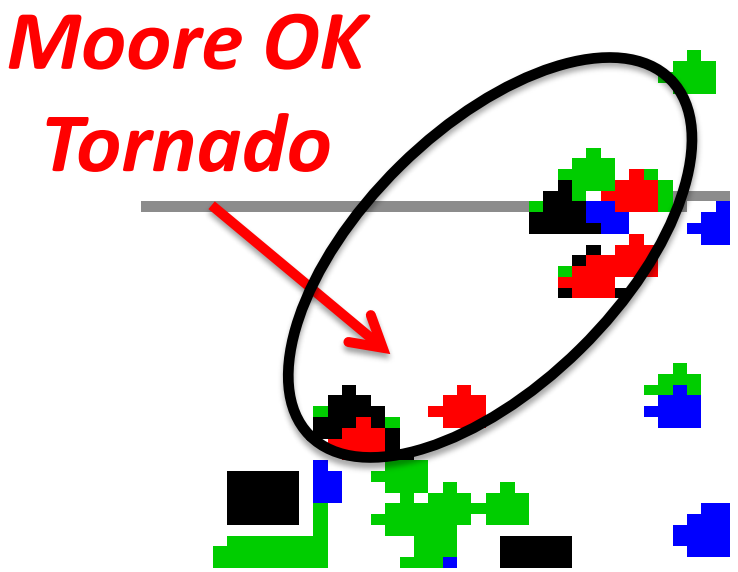
3 to -5 Unstable: Thunderstorm Probable

0 to -2 Marginally Unstable: Thunderstorms Possible

>0: Stable: Thunderstorms Unlikely

Suomi-NPP CrIS Instability Vs Tornado Reports





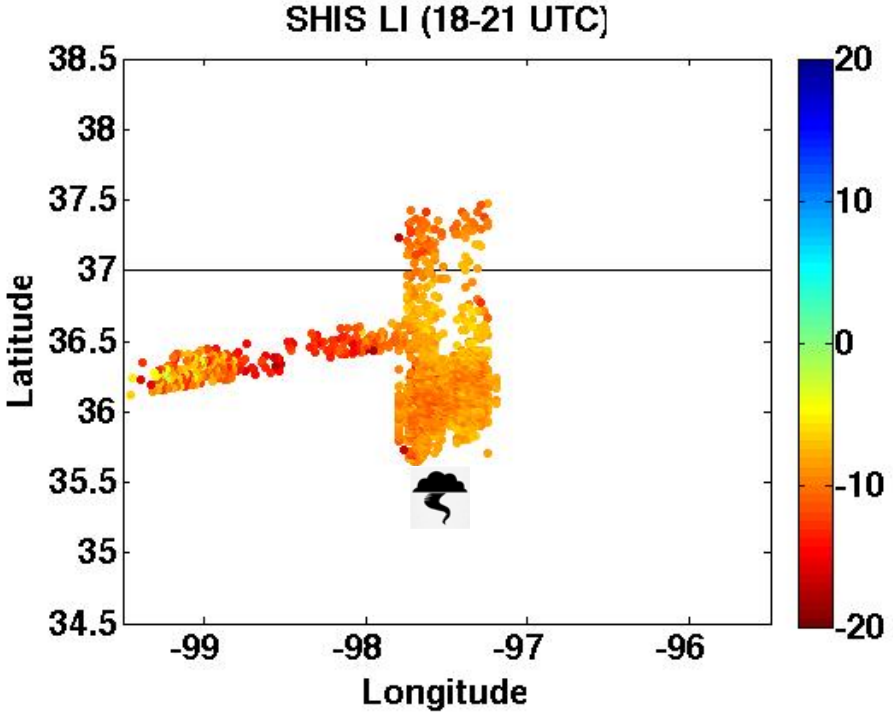
Thunderstorm Potential:

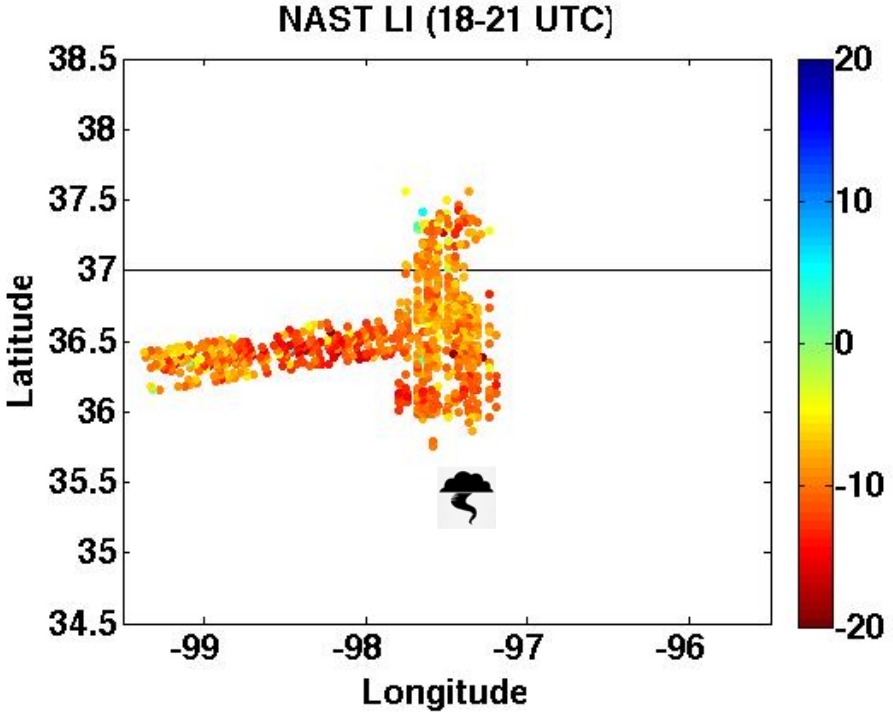
< -5 Very Unstable: Strong Thunderstorm Potential

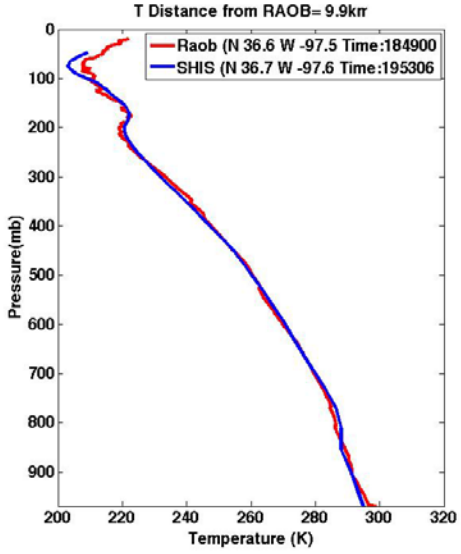
3 to -5 Unstable: Thunderstorm Probable

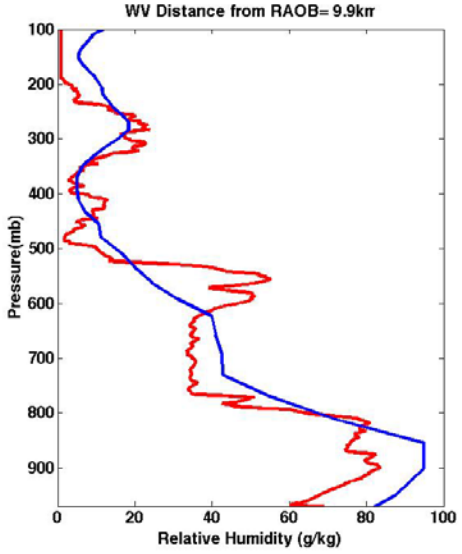
0 to -2 Marginally Unstable: Thunderstorms Possible

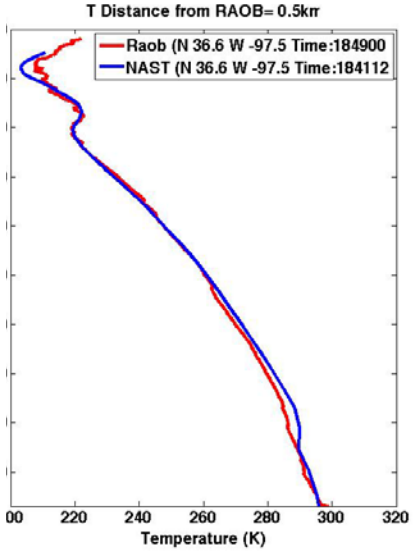
>0: Stable: Thunderstorms Unlikely

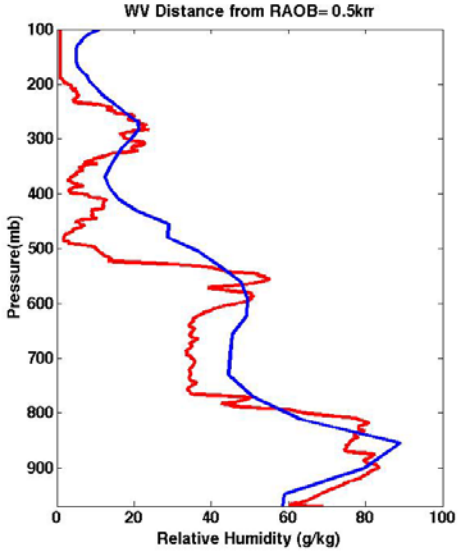

SHIS LI (18-21 UTC)
Latitude
Longitude
38.5
38
37.5
37
36.5
36
35.5
35
34.5
-99
-98
-97
-96
20
10
0
-10
-20


NAST LI (18-21 UTC)
Latitude
Longitude
38.5
38
37.5
37
36.5
36
35.5
35
34.5
-99
-98
-97
-96
20
10
0
-10
-20

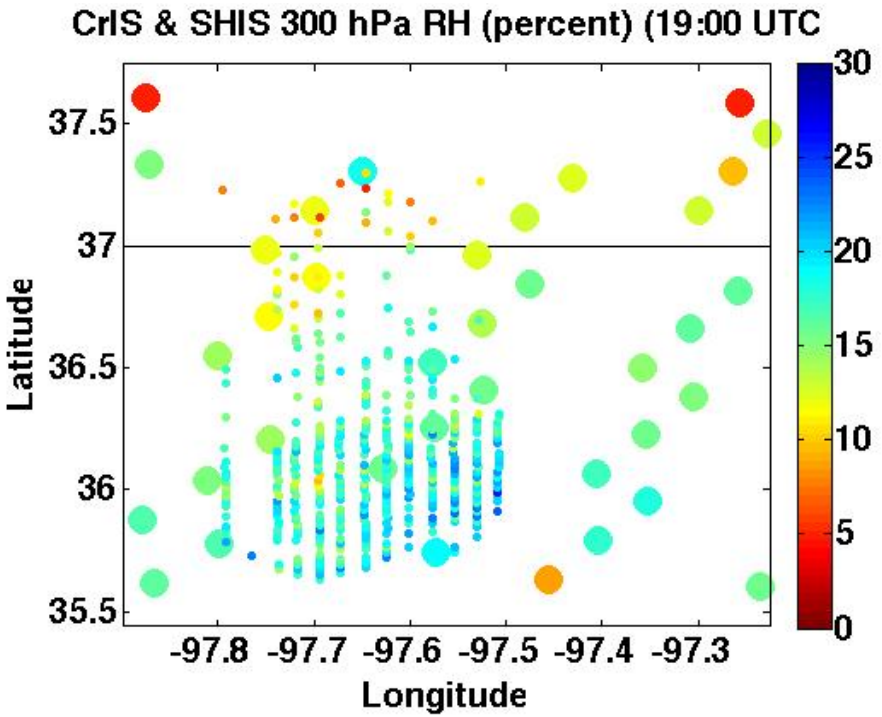

T Distance from RAOB= 9.9km
Raob (N 36.6 W -97.5 Time:184900
SHIS (N 36.7 W -97.6 Time:195306
Pressure(mb)
Temperature (K)

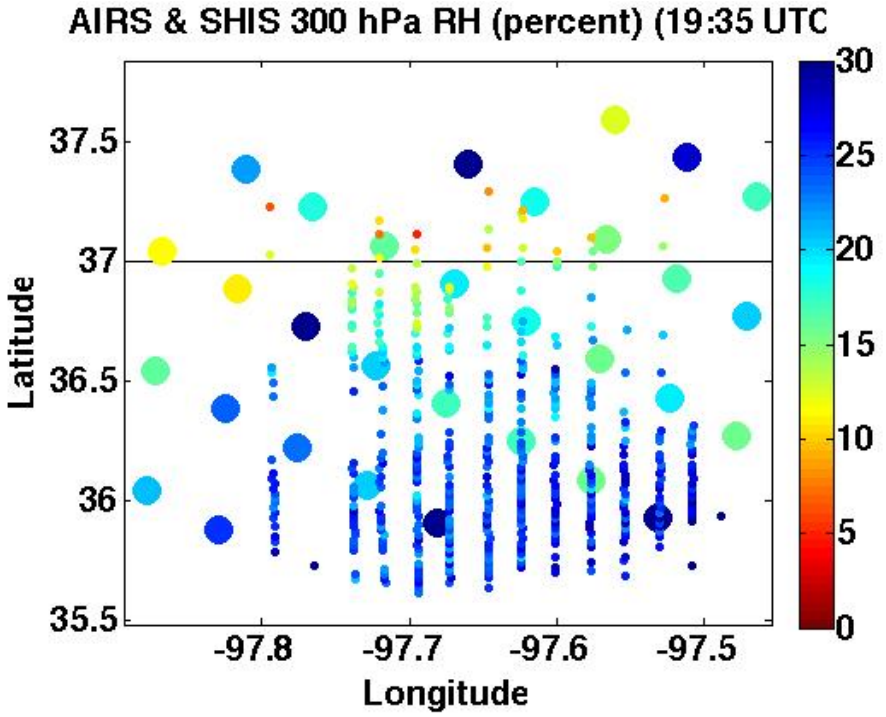

WV Distance from RAOB= 9.9km
Pressure(mb)
Relative Humidity (g/kg)


T Distance from RAOB= 0.5km
Raob (N 36.6 W -97.5 Time:184900
NAST (N 36.6 W -97.5 Time:184112
Temperature (K)


WV Distance from RAOB= 0.5km
Pressure(mb)
Relative Humidity (g/kg)

ER-2 Aircraft Soundings Are Used to Validate Satellite Sounding Time Variations





High spatial resolution (1 – km) ER-2 aircraft soundings are used to validate 35 minute time changes in relative humidity indicated by consecutive CrIS and AIRS humidity soundings

Summary and Conclusions

- CrIS provides retrievals with an accuracy and spatial resolution comparable or better than IASI and AIRS.
- ER-2 SHIS and NAST retrievals can be used to validate time tendencies of high spatial resolution features diagnosed from consecutive satellite
- Satellite soundings provide mesoscale features not yet resolved by the highest spatial resolution NWP models (i.e., RAP/WRF)
- Next step is to validate mesoscale features of Chemistry retrievals already obtained with the thermodynamic retrievals shown here.

Thank You for Your Attention