

# Examining Spatial Heterogeneity in AIRS using MODIS

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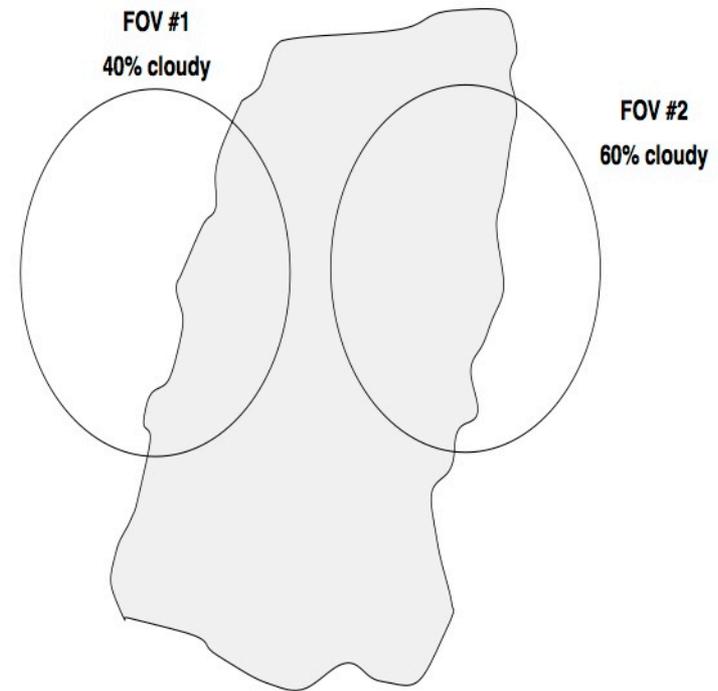
1. NASA JPL / California Institute of Technology
2. Riverside Technology inc.
3. NOAA/NESDIS

# Motivation

Simple Case

$$R_1(n) = (1 - \alpha_1)R^{clr}(n) + \alpha_1R^{cld}(n)$$

$$R_2(n) = (1 - \alpha_2)R^{clr}(n) + \alpha_2R^{cld}(n)$$



- Assumes the difference in  $R_1$  and  $R_2$  are due only to cloud fractions

$\alpha_{k,j}$  : cloud fraction for cloud k in FOV j

$R_j(n)$  : Radiance in FOV j at channel n

\* Image from Barnet's famous Remote Sensing Notes

# Motivation

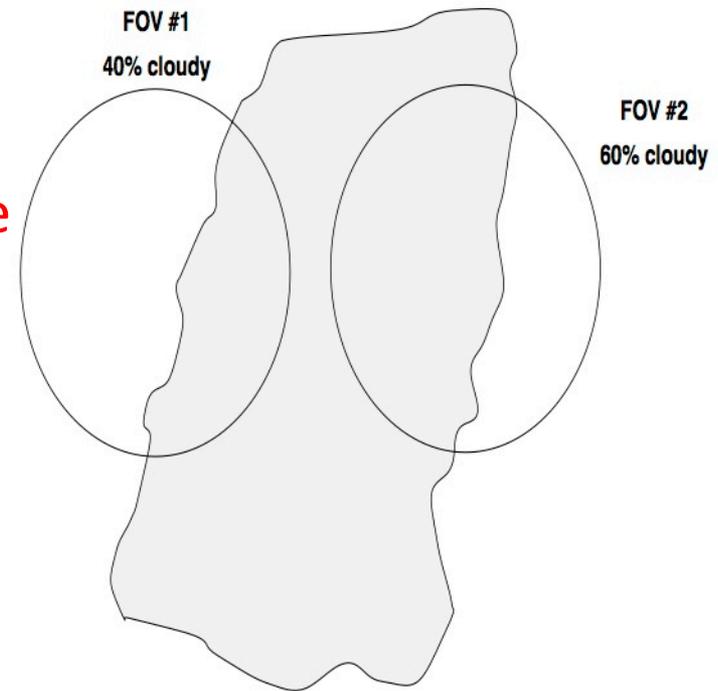
Simple Case

$$R_1(n) = (1 - \alpha_1)R^{clr}(n) + \alpha_1R^{cld}(n)$$

$$R_2(n) = (1 - \alpha_2)R^{clr}(n) + \alpha_2R^{cld}(n)$$

- Assumes the difference in radiance is due only to cloud fractions

What if  $R^{clr}$  is not the same in each FOV?



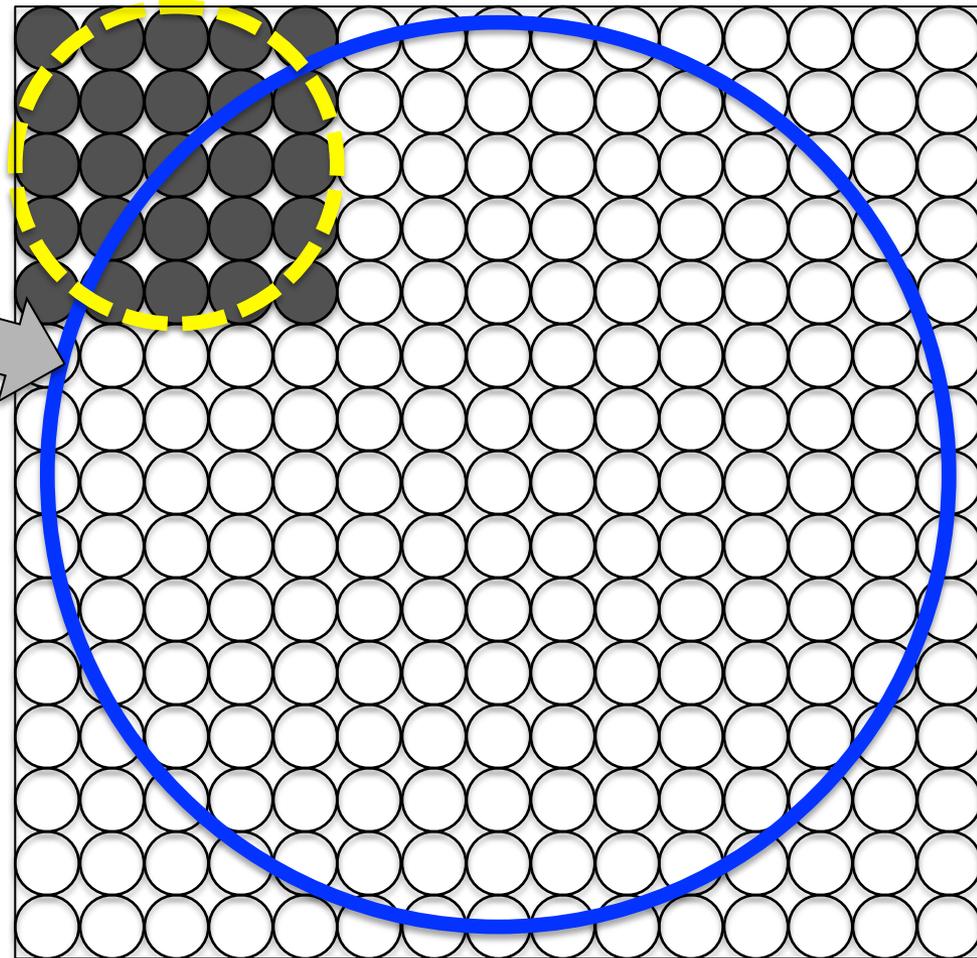
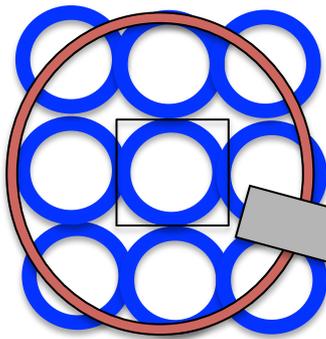
$\alpha_{k,j}$  : cloud fraction for cloud k in FOV j

$R_j(n)$  : Radiance in FOV j at channel n

\* Image from Barnet's famous Remote Sensing Notes

# Sub-Pixel Information for Sounder from Imager

## The different Fields of View (FoV)

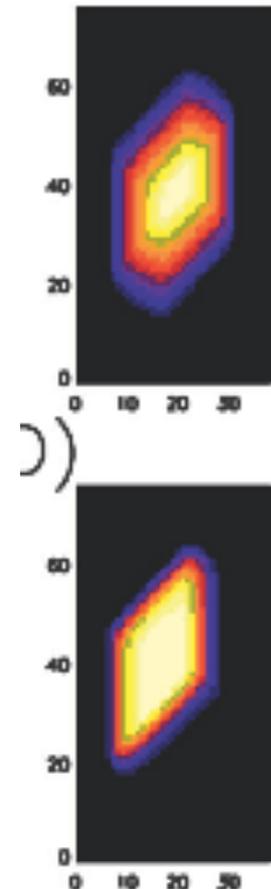
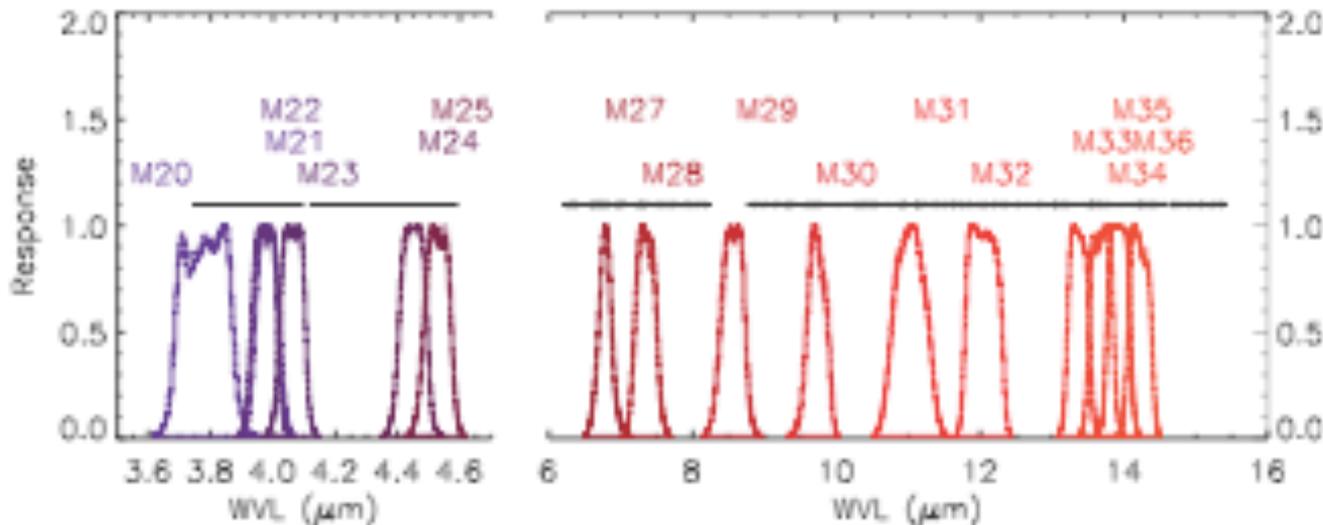


AIRS/AMSU product: 45 km (orange)  
AIRS FoV ~ 15km (blue)  
MODIS Level 2: 1-5km (black/yellow)  
MODIS Radiances: 0.25-1km (black)

MODIS provides information about clouds within the AIRS-FoV

# AIRS MODIS Collocation

- Schreier et al 2010 describes a method to compare MODIS radiances to AIRS Radiances
- AIRS is spectrally convolved to MODIS channels 31 and 32
- MODIS is spatially convolved to AIRS field of view



# AIRS Clear Cases defined by MODIS

- Use MODIS clear flag to determine when AIRS has a clear FOV
- 2 days analyzed: 2013-02-03 and 2013-02-04
- Require at least 3 AIRS FOV's be clear
- Roughly 1-2% clear in both L1 and L2

February 3

	Level 1b	Level 2
Total	2916000	324000
Clear	71700	8709
Ocean	57506	6646
Land	13814	1911
Mix	380	152

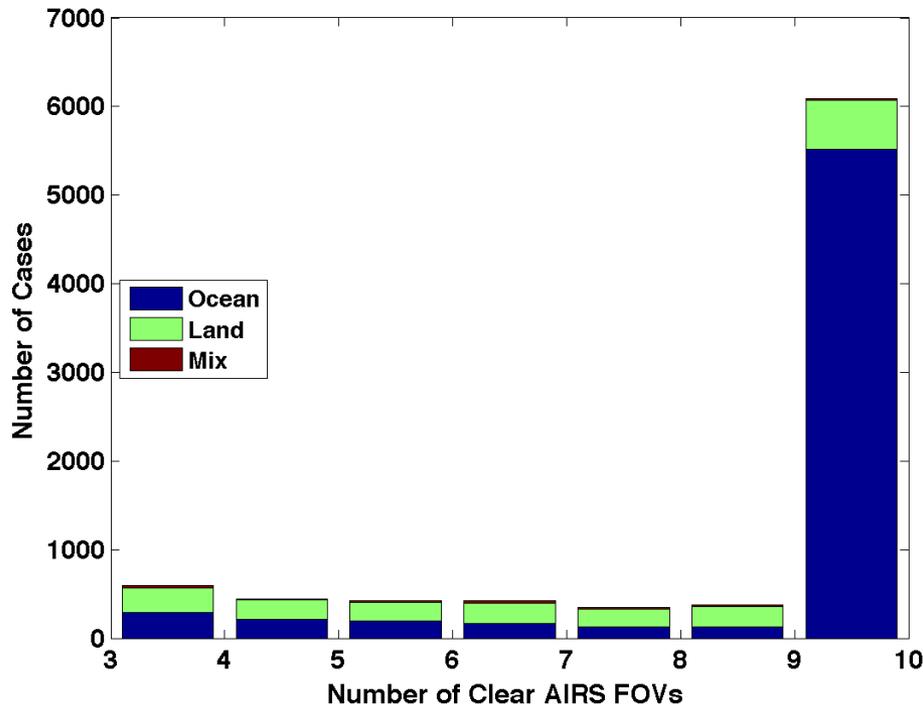
February 4

	Level 1b	Level 2
Total	2916000	324000
Clear	41902	6014
Ocean	17828	2400
Land	23365	3329
Mix	709	285

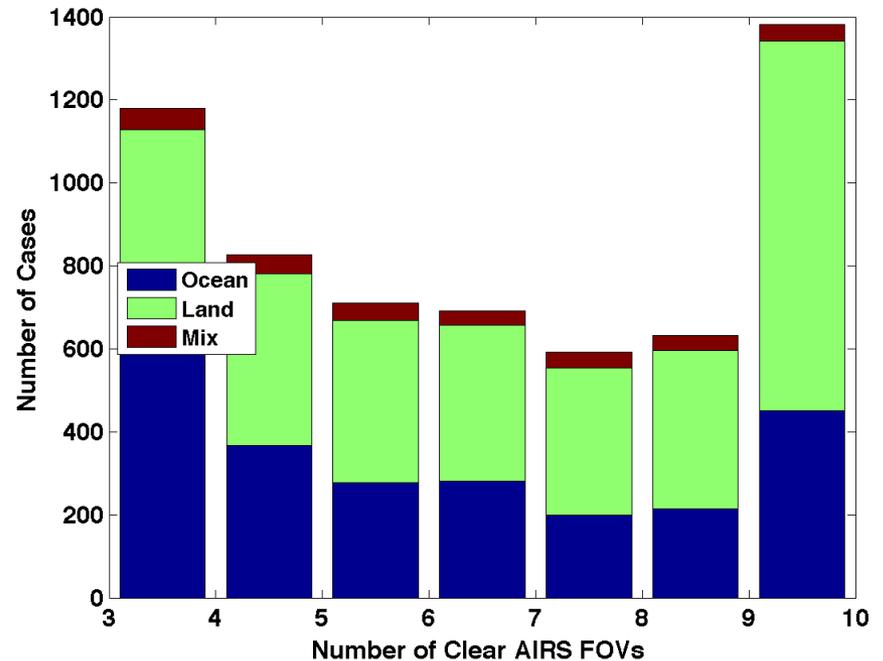
# Number of clear AIRS FOVS in the 3x3

- Most cases with at least one clear AIRS FOV are completely clear for February 3
- February 4 has many more land cases
- Using MODIS to determine how much of AIRS is clear

20130203 AIRS Clear FOVS Inside the 3x3

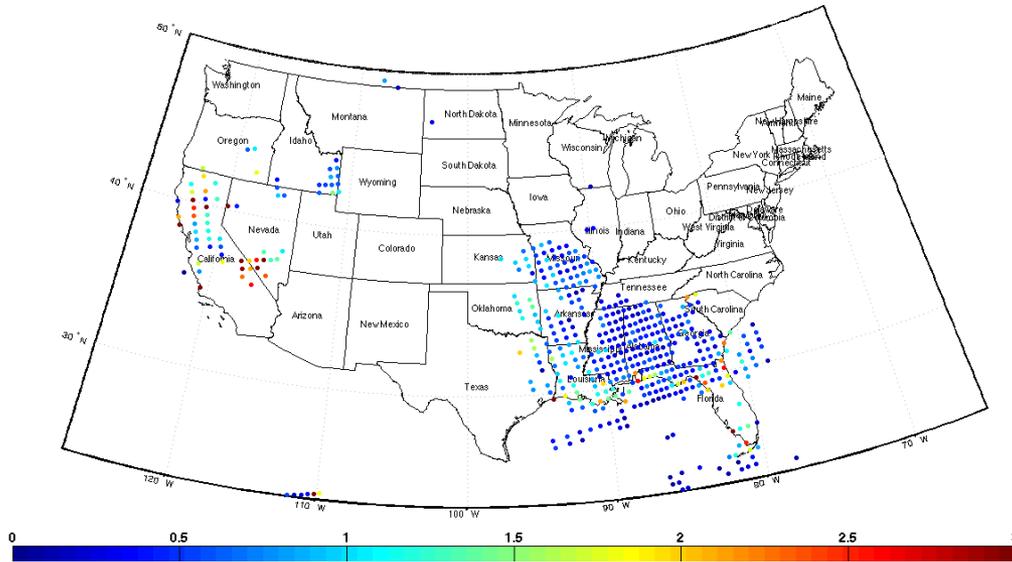


20130204 AIRS Clear FOVS Inside the 3x3



# Examples of Heterogeneity: STD

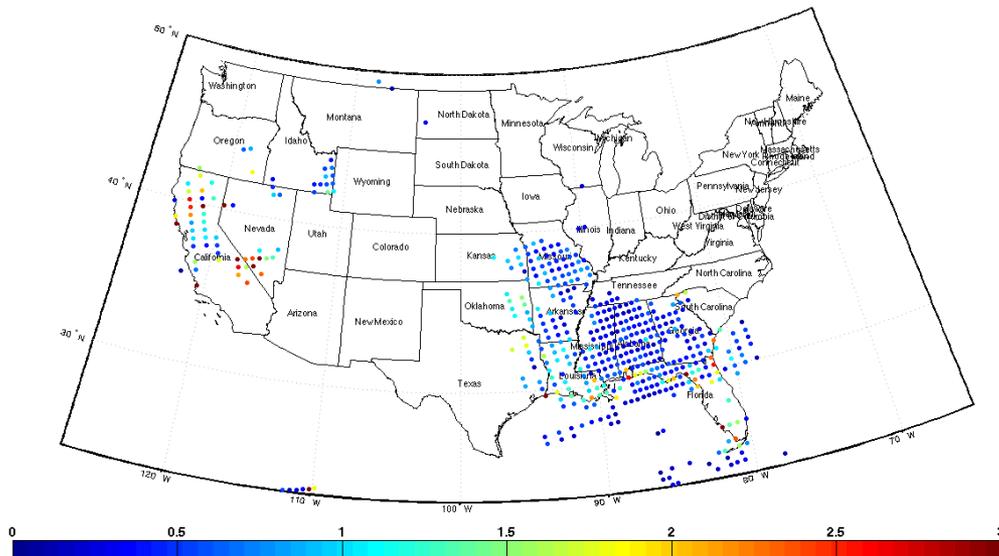
20130203 STD in the 3x3 CH 31



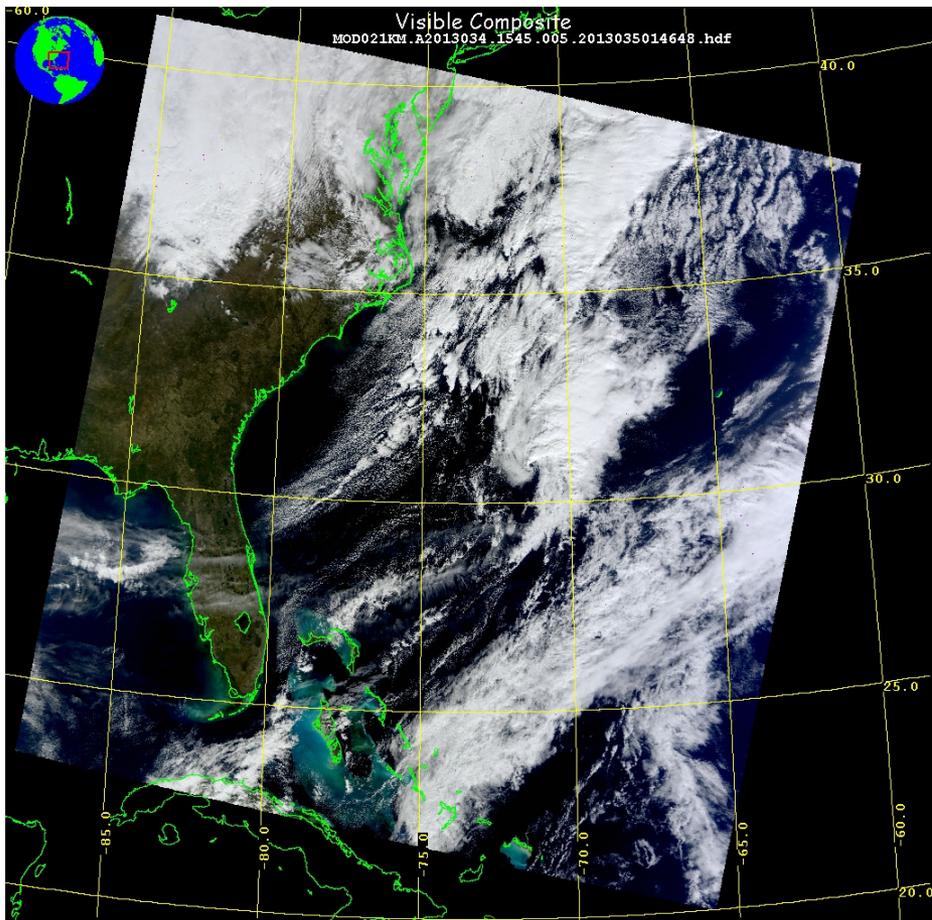
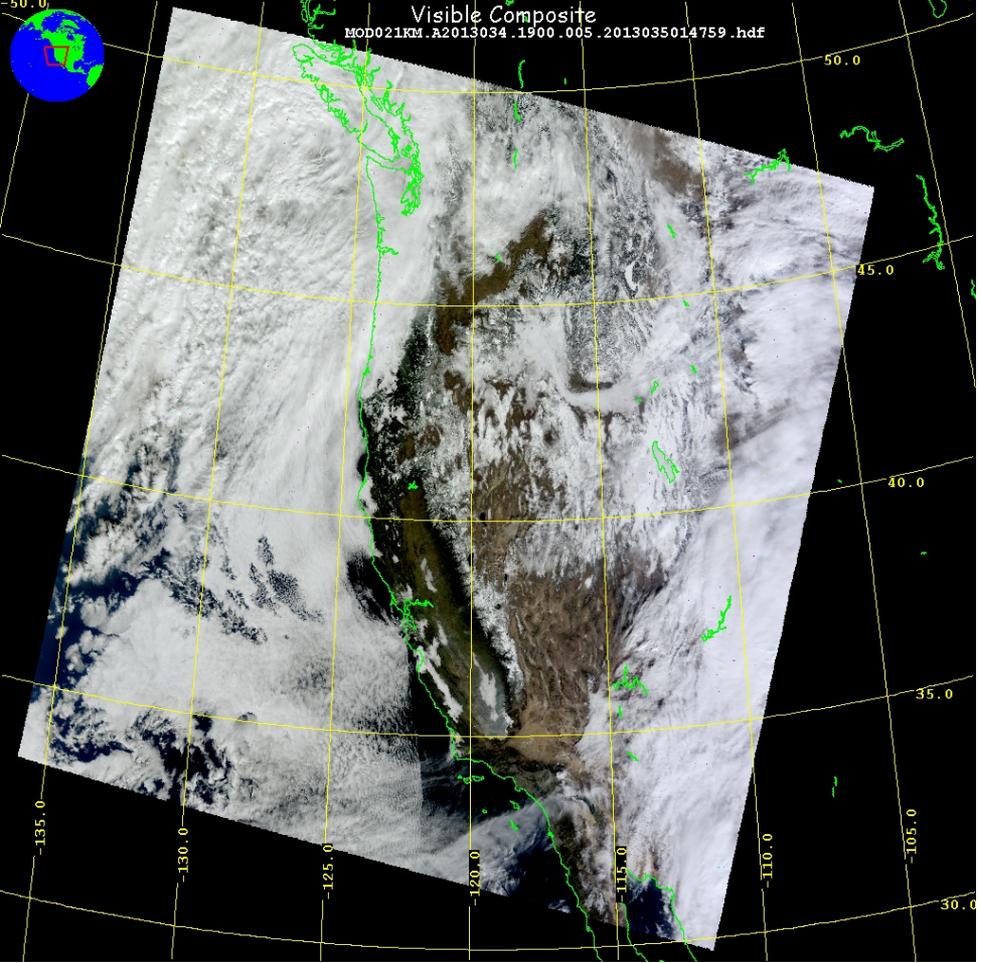
- Standard deviation of all clear pixels in the 3x3
- MODIS CH31 and CH32 are collocated to AIRS (surface channels)

STD > 3K over death valley

20130203 STD in the 3x3 CH32



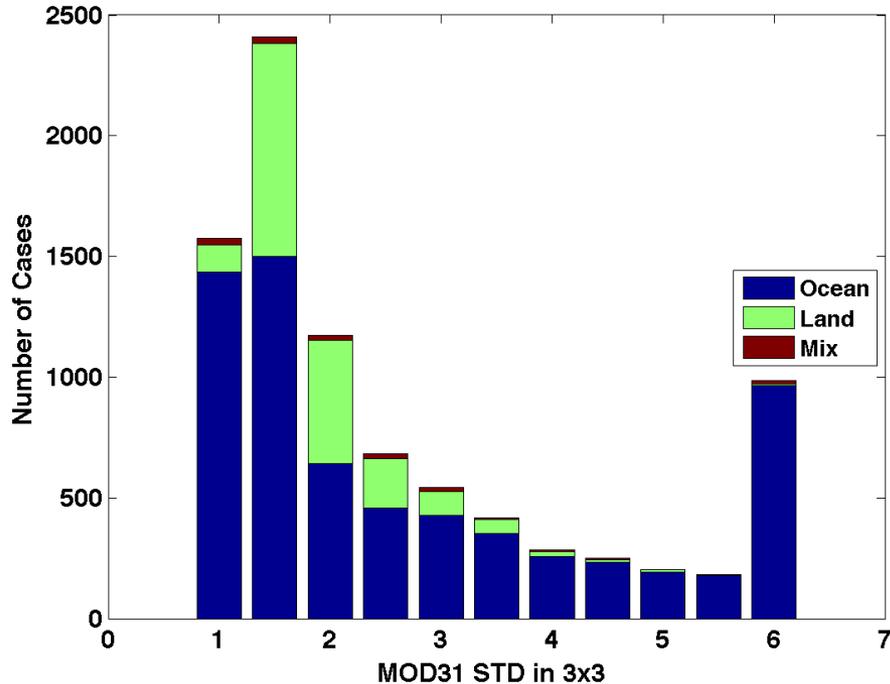
Not much difference between channels 31 and 32



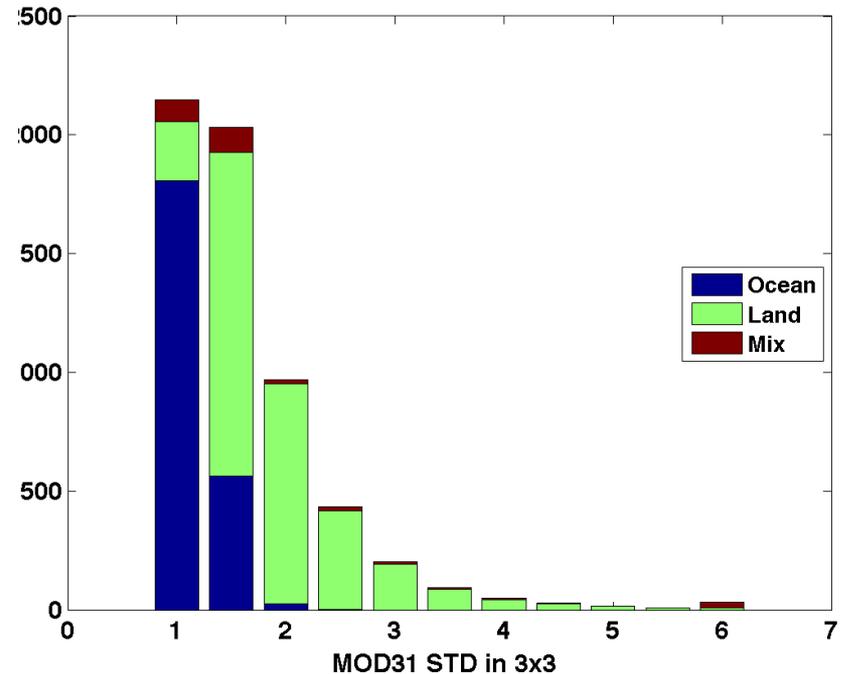
# Histogram of the STD in the 3x3

- Most Ocean scenes have less than 1.5K STD in the 3x3 (At least for 20130204)
- High STD in 20130203 may be due to suspect granule
- More analysis necessary on 20130203 ocean scenes
- Distribution for 20130204 makes intuitive sense

20130203 CH31 STD in 3x3



20130204 CH31 STD in 3x3

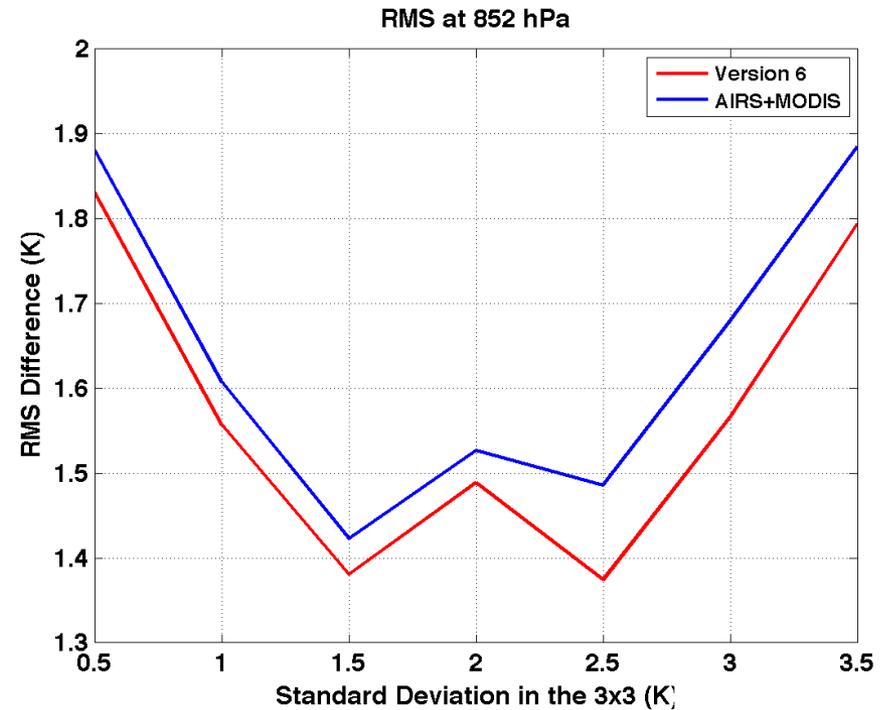
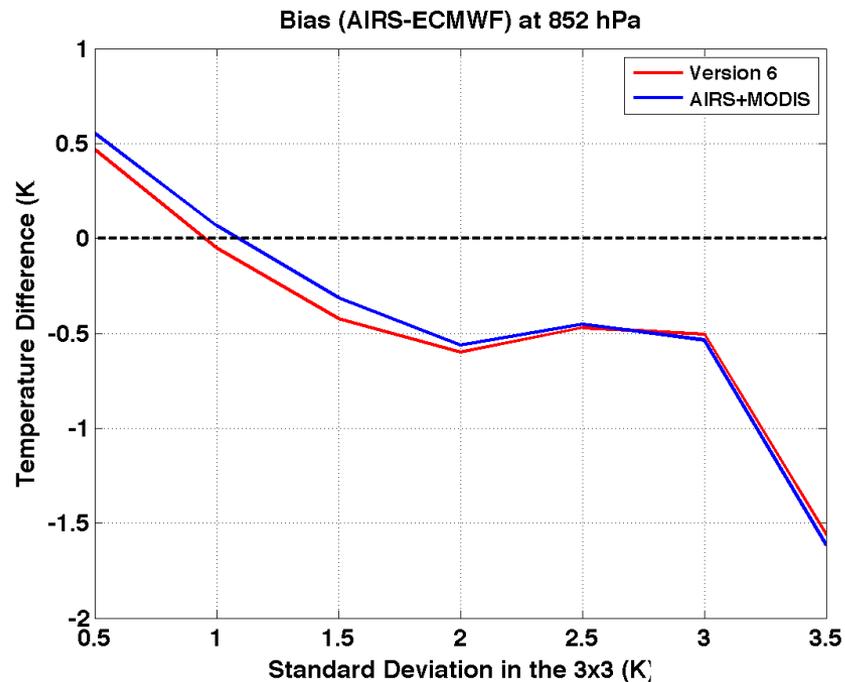


# Retrieval Comparisons

- Matchup AIRS v6 and a research version retrieval to ECMWF for 20130203 (Land Only)
- Research version uses MODIS to generate cloud cleared radiances
- Research version is suboptimal because we forced the CCR's in the V6 algorithm

# Retrieval comparisons as a function of STD in the 3x3 (near surface)

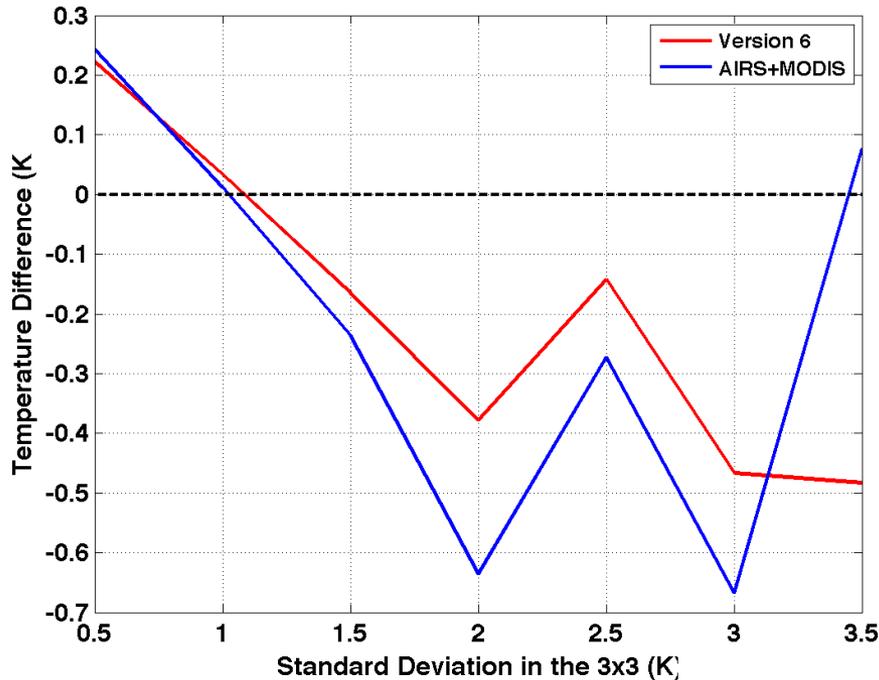
- STD is calculated only for retrievals with at least 3 clear AIRS FOVs
- Bias becomes strongly negative (ECMWF > AIRS) for high STD
- AIRS + MODIS uses only 2 AIRS FOVs so its interesting that its follows V6 so closely



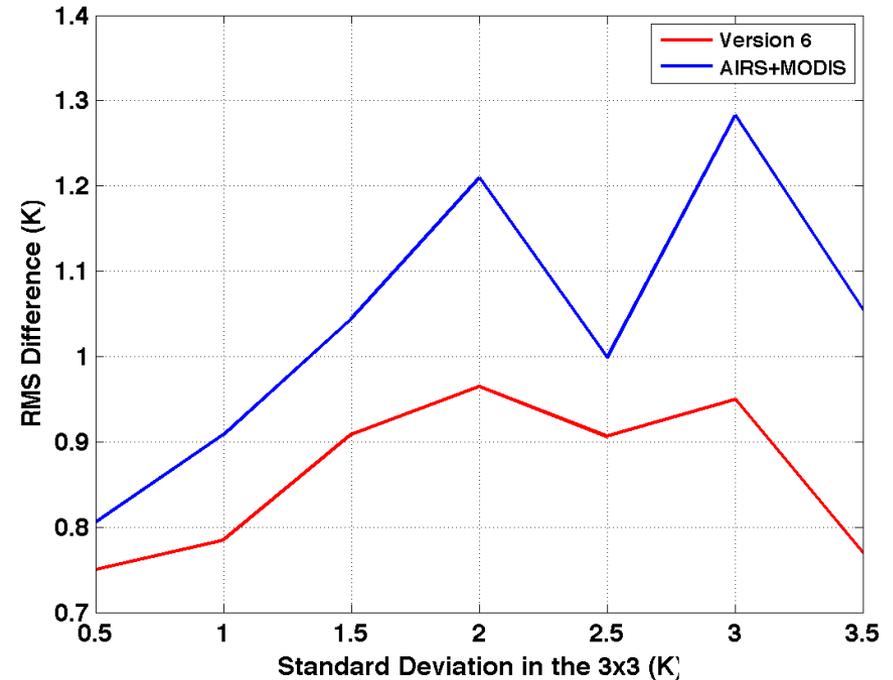
# Retrieval comparisons as a function of STD in the 3x3 (mid troposphere)

- Bias becomes negative but is less affected than at 852 hPa
- STD is from MODIS channel 31 so it makes sense that the middle troposphere would be less affected

Bias (AIRS-ECMWF) at 515 hPa

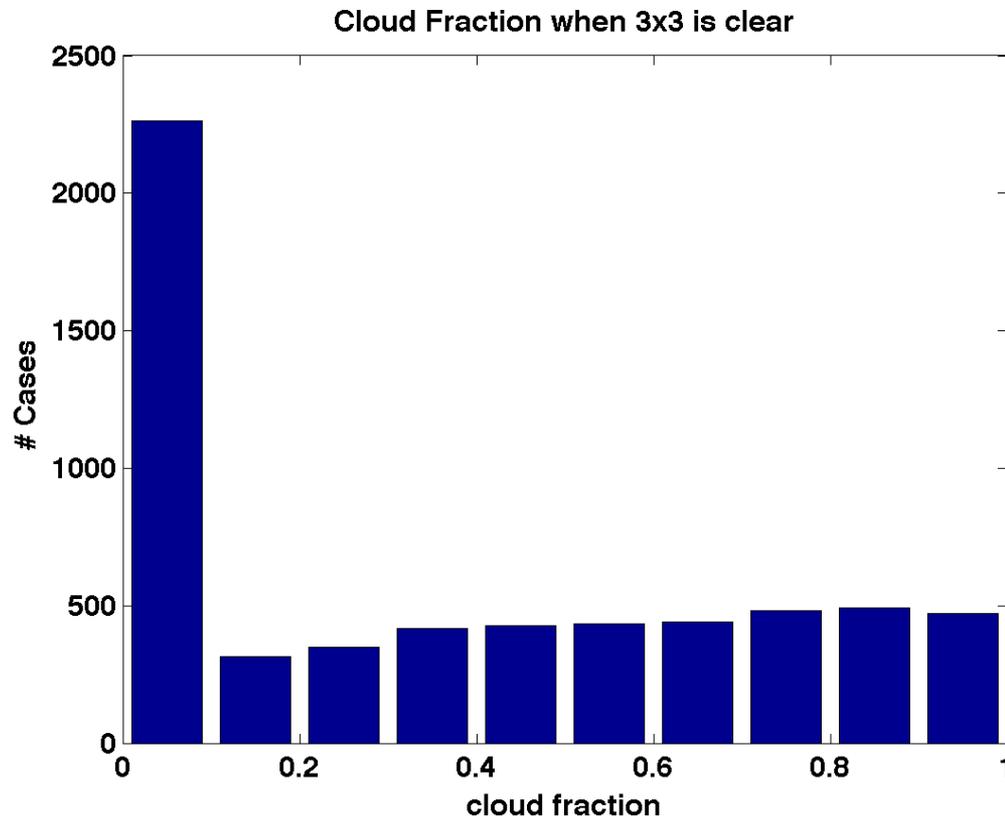


RMS at 515 hPa



# Fictitious Clouds ?

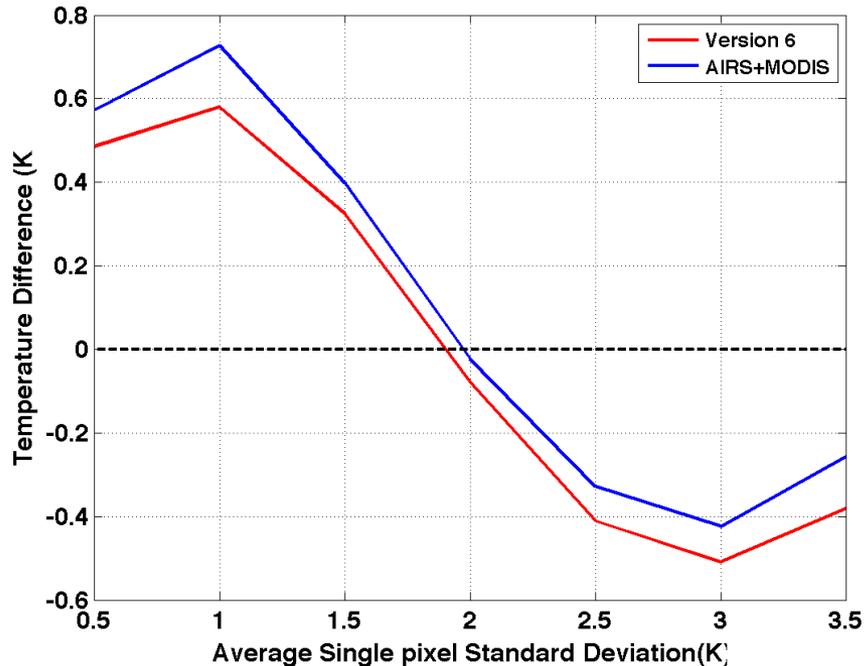
- All 9 AIRS FOVs are determined clear by MODIS
- Can surface heterogeneity cause the retrieval to think the scene is cloudy?



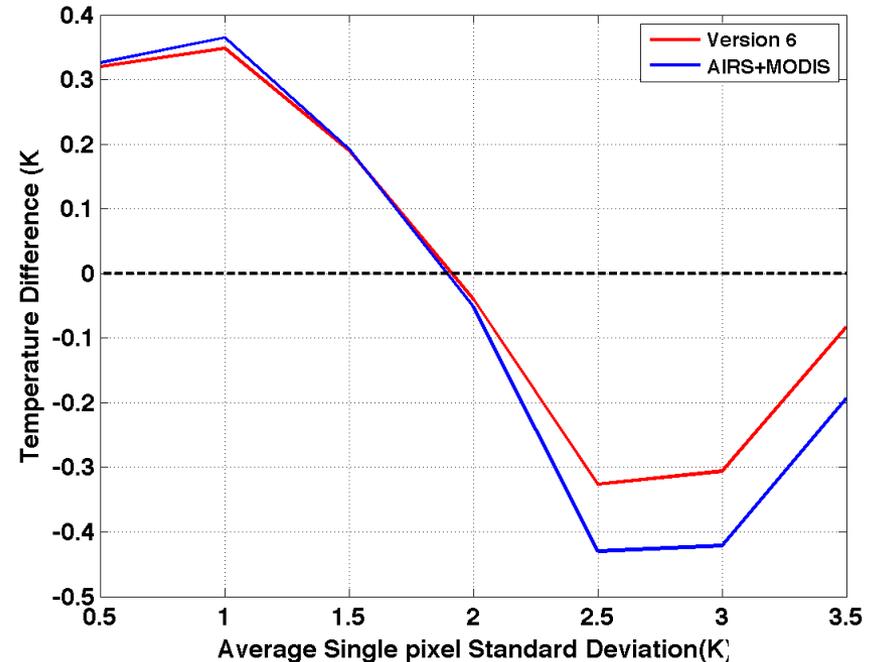
# Heterogeneity in single AIRS pixel

- Use MODIS to find the STD in a single AIRS FOV
- Take the average of the STD in all clear pixels for the 3x3
- 515 hPa bias has similar behavior and with a smaller amplitude in the bias

Bias (AIRS-ECMWF) at 852 hPa



Bias (AIRS-ECMWF) at 515 hPa

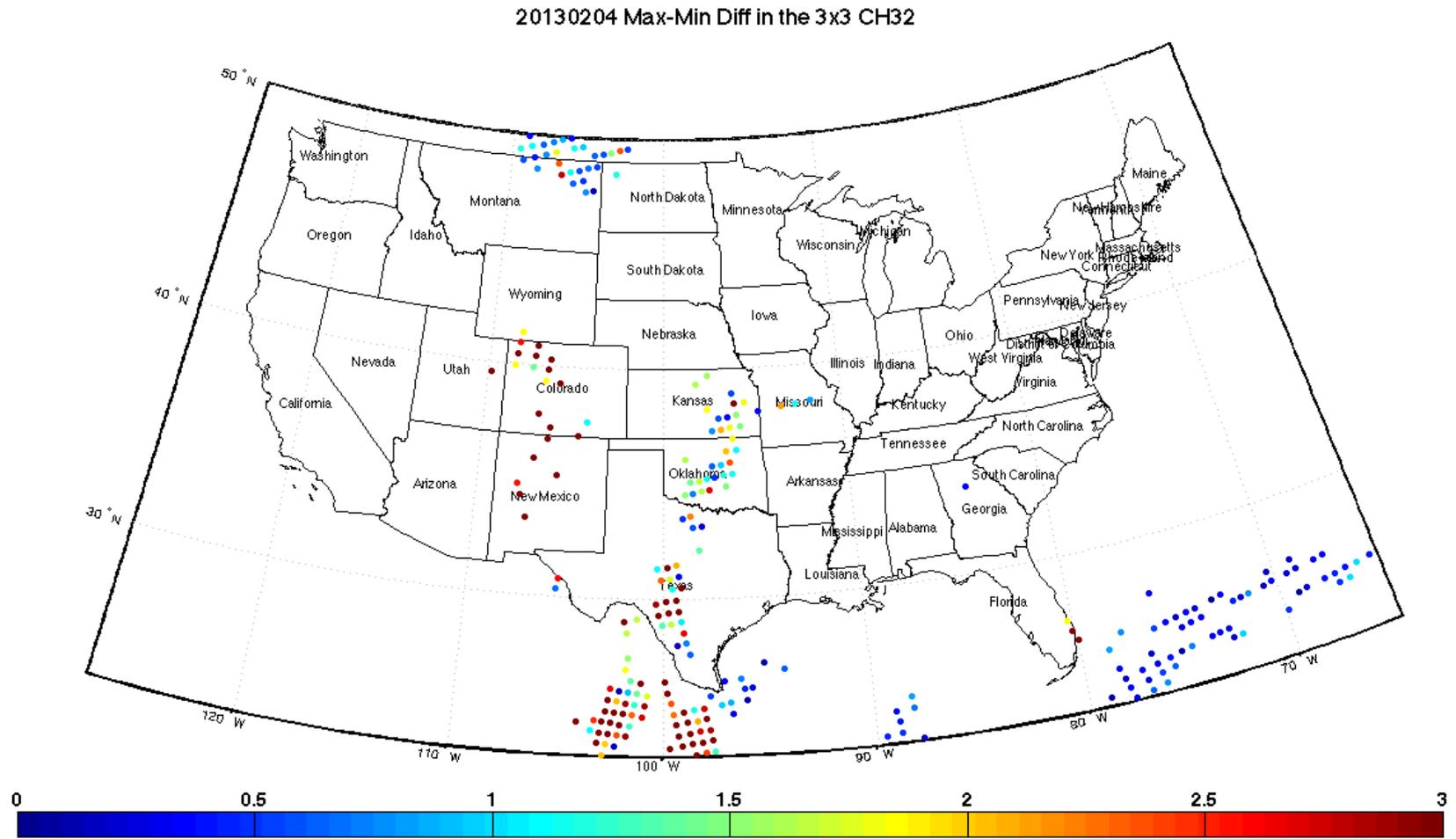


# Conclusions

- 3x3 heterogeneity has a much larger impact on the retrieval than sub pixel heterogeneity
- Surface channels can have differences on the order of a few Kelvin in a 3x3 grid
- Land/Mix surface types contain most of the highly heterogeneous scenes
- Temperature retrieval bias becomes more negative as heterogeneity increases
- Heterogeneity may cause fictitious clouds in the retrieval?

# Examples of Heterogeneity :Max - Min

- Values in the Gulf of Mexico even have differences of 3K



# Examples of Heterogeneity :Max - Min

- Many values are greater than 3K including the southeast

20130203 Max-Min Diff in the 3x3 CH31

