Atmospheric Compensation for a Landsat Land Surface Temperature Product

Monica Cook
John R Schott
Digital Imaging and Remote Sensing Laboratory
Chester F. Carlson Center for Imaging Science
Rochester Institute of Technology

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A Land Surface Temperature Product

Approach – Focus initial efforts on north America to take advantage of available data

- NAALSED (N.A. Emissivity maps)
- NARR (N.A. Met data)

– Use North America to clarify how to do Globe

- Same approach with more interpolation of atmospheres & lower resolution emissivities
- Identify/develop better global reanalysis
- Build higher resolution global emissivity maps

A Land Surface Temperature Product

Implement Approach

Calibrate data base: Goddard, JPL, RIT

- L4, L5, L7 Updated trusted calibrations available – final error assessment ongoing

Atmospheric Compensation: RIT

Emissivity values:

Cloud Screening

- Clouds classified by height and appearance (texture)
- More interested in texture than height

Strato- = layer (uniform, widespread, layered)

Cumulo- = heap (cellular, individual elements)

Cirro- = high

Alto- = mid

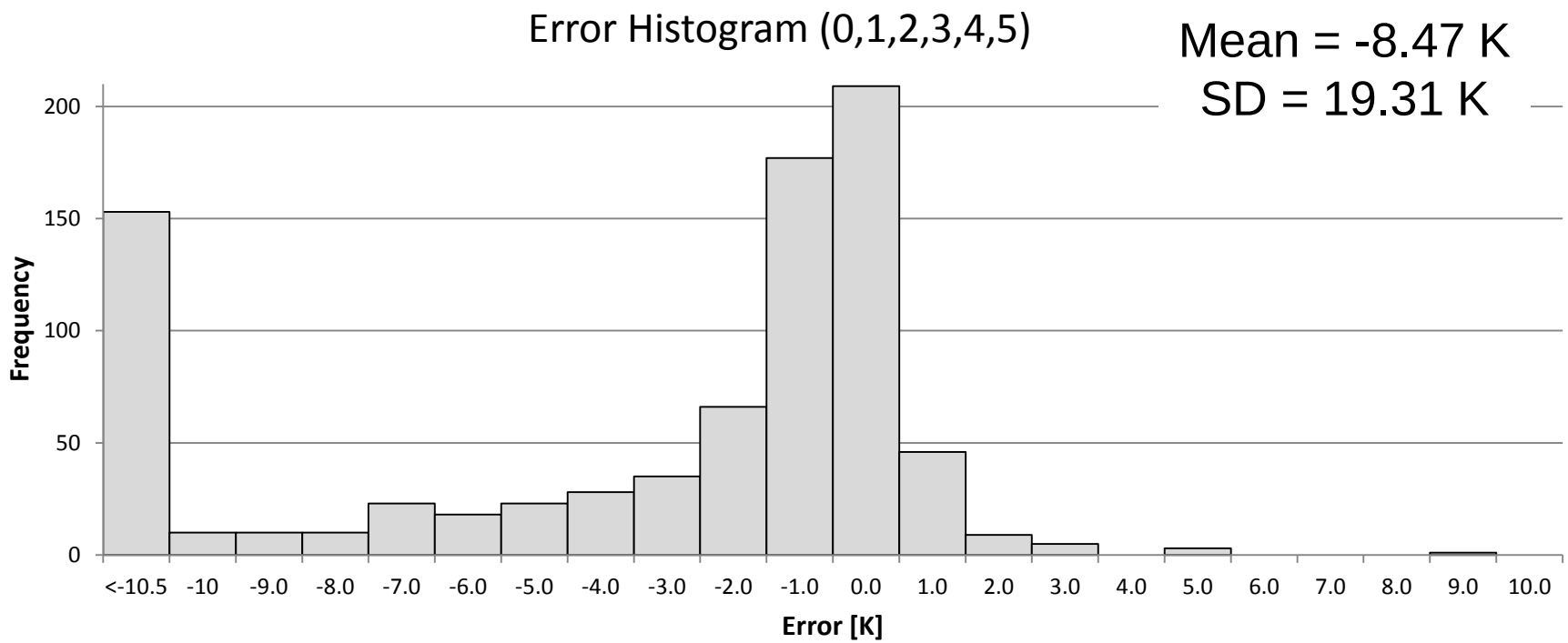
- **Cumulus** includes cirrocumulus and altocumulus
- **Stratus** includes cirrostratus, altostratus, stratocumulus, and nimbostratus
- **Cirrus** clouds are wispy, feathery clouds (widespread)

Landsat 5 ,Cloud Screening 826 scenes, NARR atmospheres,NOAA buoys supply truth

Category	Description	Number of Scenes	% of Scenes
0	Cloud Free	259	31.3%
1	Cumulus in vicinity	98	11.9%
2	Stratus or Cirrus in vicinity	158	19.1%
3	Cumulus over buoy	60	7.3%
4	Stratus or Cirrus over buoy	202	24.4%
5	Totally cloudy image	50	6.0%

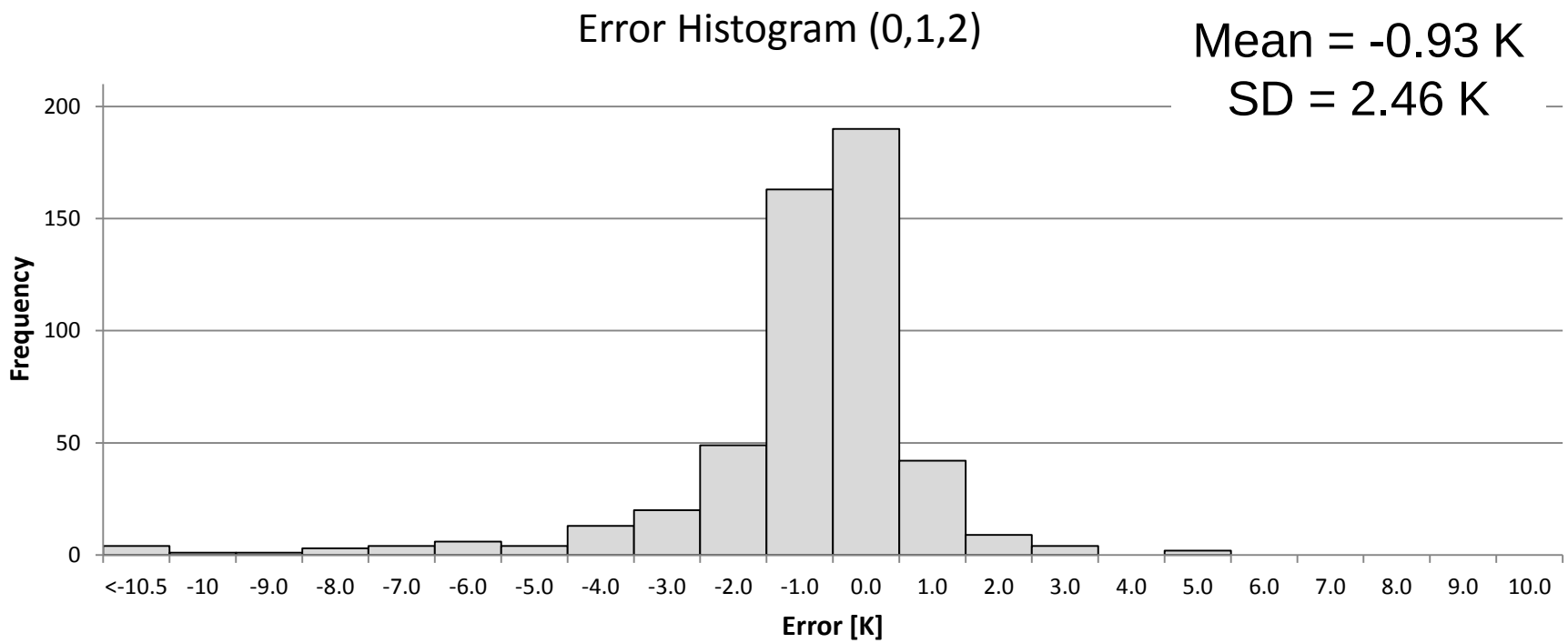
L5 NARR

826 scenes
≈100%
Mean = -8.47 K
SD = 19.31 K



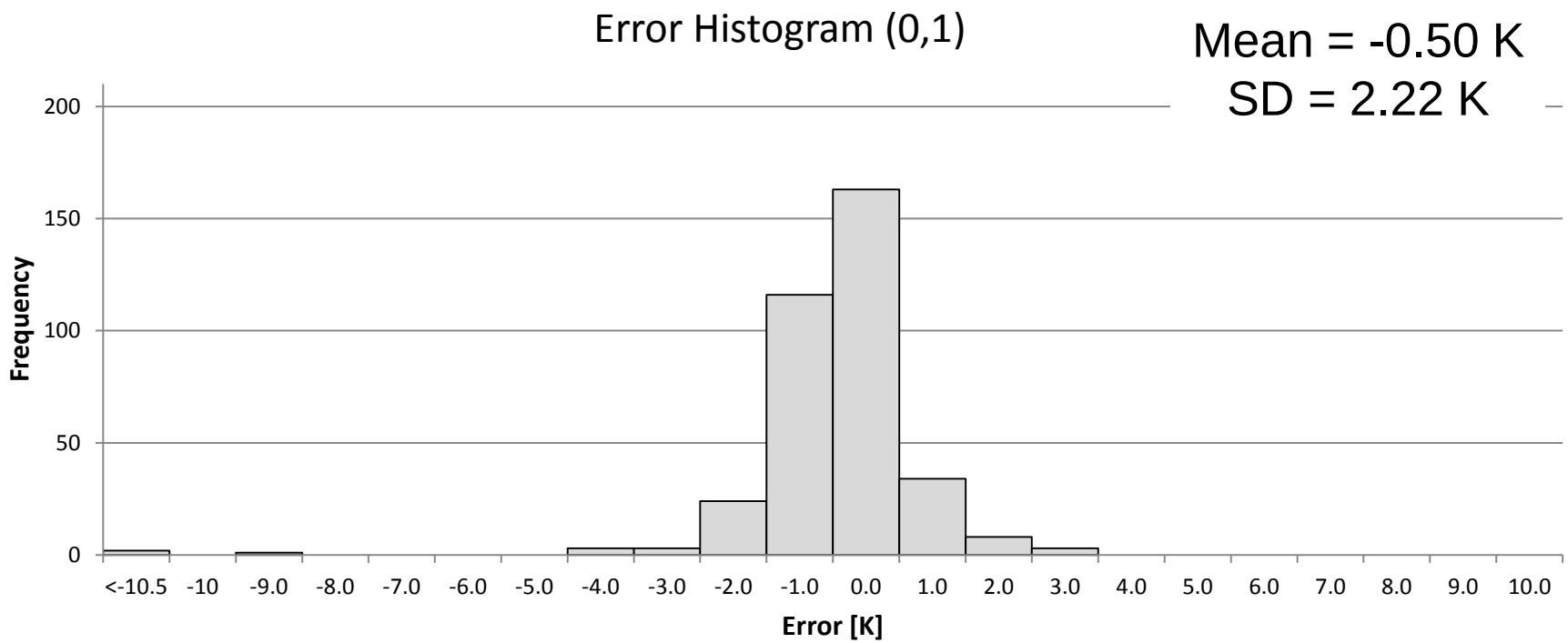
L5 NARR

515 scenes
62%
Mean = -0.93 K
SD = 2.46 K



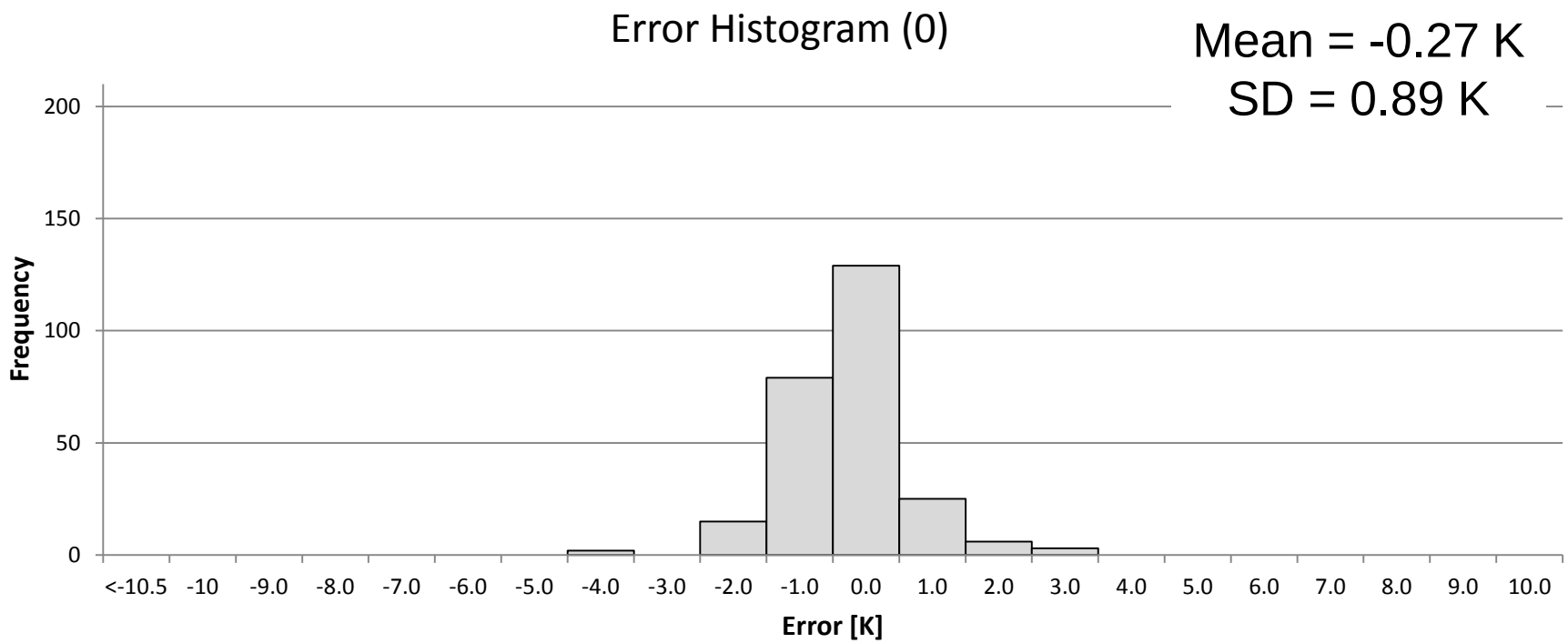
L5 NARR

357 scenes
43%
Mean = -0.50 K
SD = 2.22 K



L5 NARR

259 scenes
31%
Mean = -0.27 K
SD = 0.89 K



Product Requirements

- Provide LST for every pixel in the scene
- Provide cloudy or error metric for every pixel in the scene

- Assuming cloud product or algorithm
- For each pixel:
  - Need cloud or no cloud
  - If no cloud, need cloud in vicinity or no cloud in vicinity

- What is cloud is vicinity?
  - Distance from current pixel to nearest cloud pixel
  - How many meters or how many pixels?

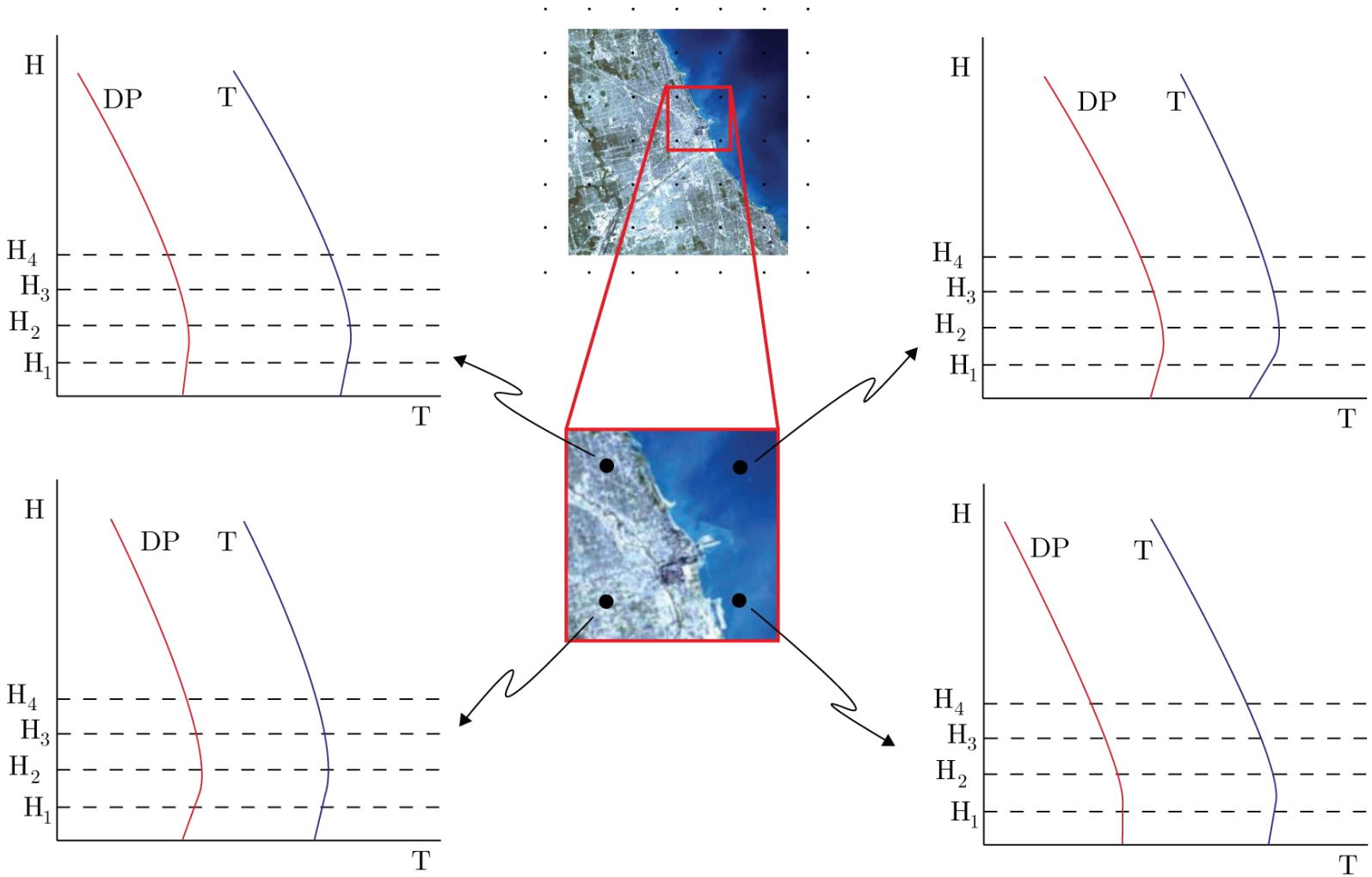
Error Conclusions

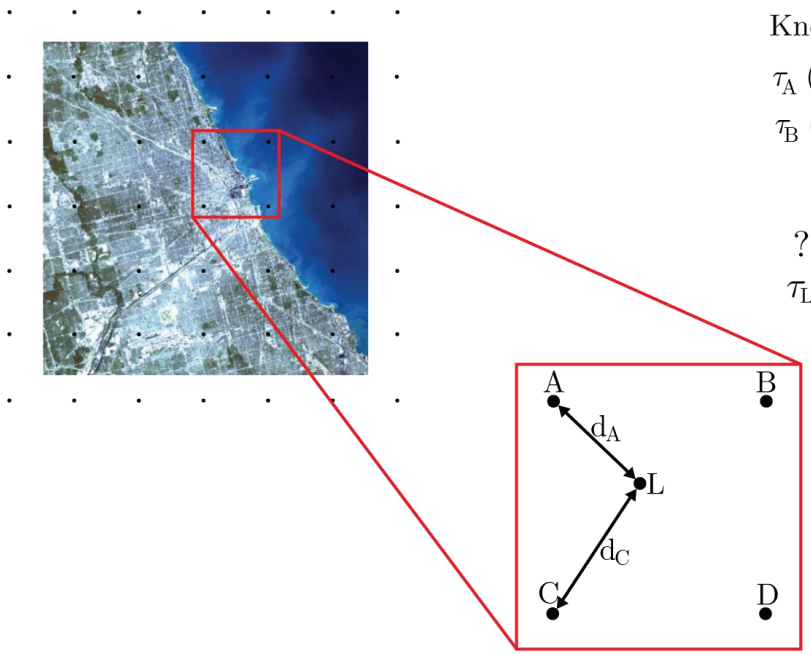
- Current expectation is these options for error metric

- For cloud free [no cloud and no cloud in vicinity] (0):
  - Mean and standard deviation of validation dataset
  - Per pixel error estimate using propagation method
- For clouds in vicinity [no cloud and cloud in vicinity] (1,2):
  - Mean and standard deviation of validation dataset
- For clouds over buoy [cloudy pixel] (3,4,5):
  - Mean and standard deviation of validation dataset
  - Strongly recommend not trusting

Next

For each node we can estimate the atmospheric parameters associated with any altitude





Know:

$\tau_A\ (H_L),\ L_{u_A}(H_L),\ L_{d_A}(H_L)$

$\tau_B\ (H_L),\ L_{u_B}(H_L),\ L_{d_B}(H_L)$

$\vdots$

?:

$\tau_L,\ L_{u_L},\ L_{d_L}$

Interpolate

Nearest neighbor → $\tau_L = \tau_A,\ L_{u_L} = L_{d_L}\ \ldots$

Linear in 1/d → $$\tau_L = \frac{\frac{\tau_A}{d_A} + \frac{\tau_B}{d_B} + \frac{\tau_C}{d_C} + \frac{\tau_D}{d_D}}{\sum_i \frac{1}{d_i}},\ \ldots$$

Linear in e^{-d} → $$\tau_L = \frac{\tau_A e^{-d_A} + \tau_B e^{-d_B} + \tau_C e^{-d_C} + \tau_D e^{-d_D}}{\sum_i e^{-d_i}},\ \ldots$$

Output: $\tau(H_L, t_L, L),\ L_u(H_L, t_L, L),\ L_d(H_L, t_L, L)$

$$L = \begin{bmatrix} x \\ y \\ H_L \end{bmatrix}$$

Building Datasets

- RIT Dataset – 827 data points for analysis
  - Salton Sea – 14 scenes
  - Lake Tahoe – 140 scenes
  - Rochester – 77 scenes
  - Delmar – 108 scenes
  - Georgia – 59 scenes
  - Cali, Santa Barbara – 94 scenes
  - Cali, Santa Monica – 113 scenes
  - Huron – 122 scenes
  - Superior – 100 scenes

Outline

- Cloud Screening Logic
- L5 Results with NARR with cloud screening
- L5 Results with MERRA with cloud screening
- L8 Results with NARR (all cloud free)

- Product Requirements and Error Conclusions

Cloud Screening

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Landsat 5 ,Cloud Screening - NARR

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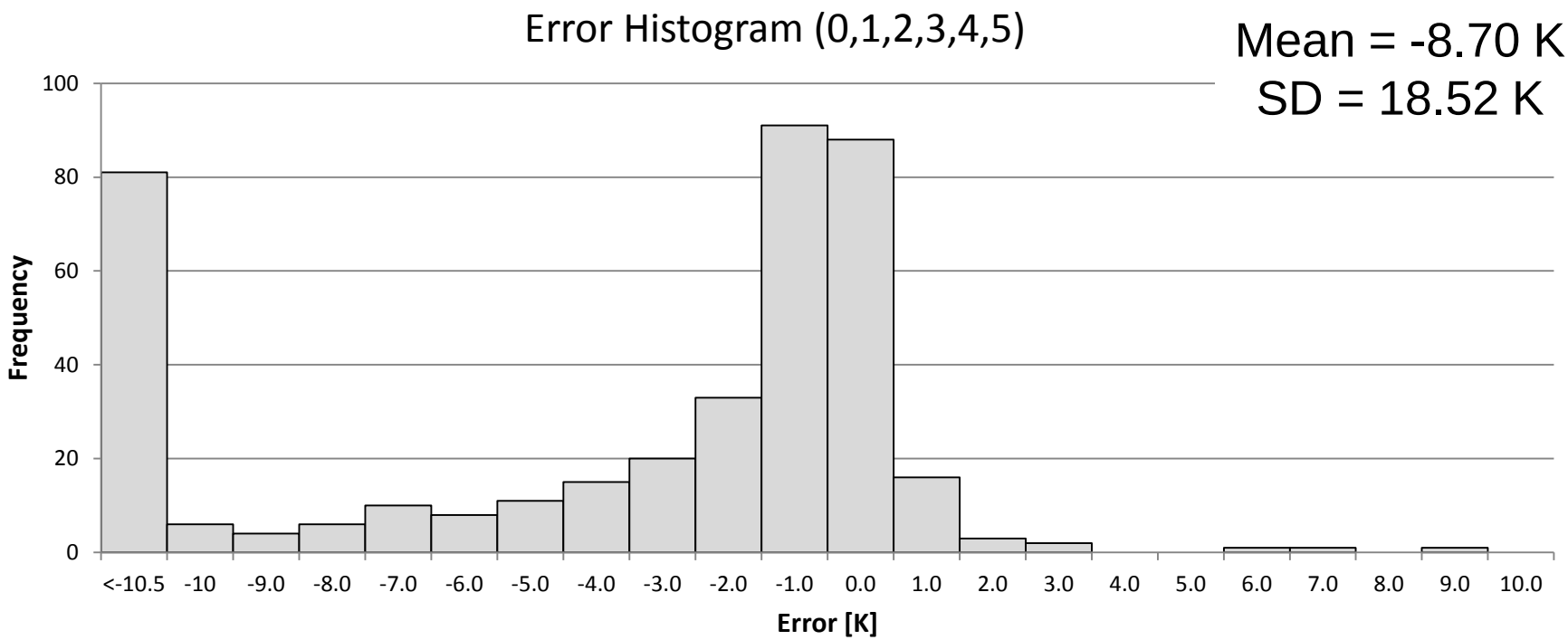
5	Totally cloudy image	50	6.0%

Cloud Screening – MERRA

Category	Description	Number of Scenes	% of Scenes
0	Cloud Free	104	26.2%
1	Cumulus in vicinity	49	12.3%
2	Stratus or Cirrus in vicinity	86	21.7%
3	Cumulus over buoy	23	5.8%
4	Stratus or Cirrus over buoy	108	27.2%
5	Totally cloudy image	27	6.8%

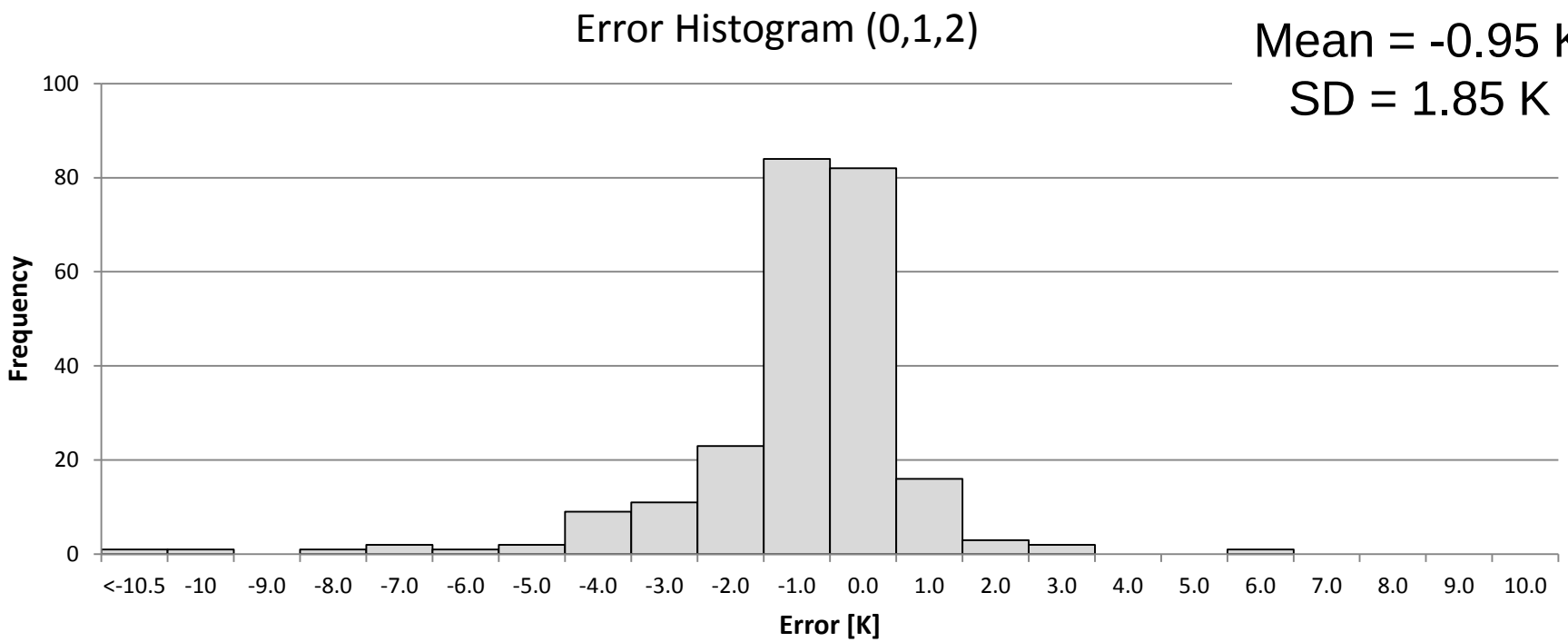
L5 MERRA

397 scenes
100%
Mean = -8.70 K
SD = 18.52 K



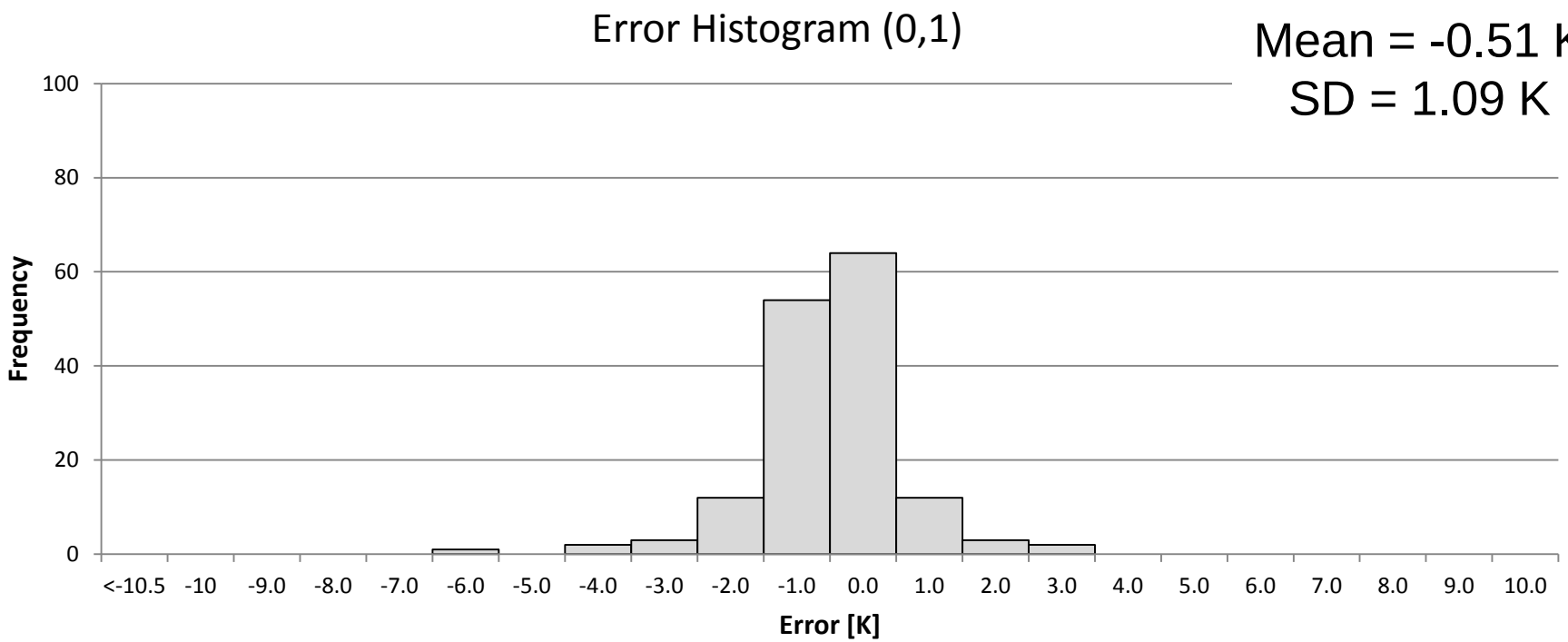
L5 MERRA

239 scenes
60%
Mean = -0.95 K
SD = 1.85 K



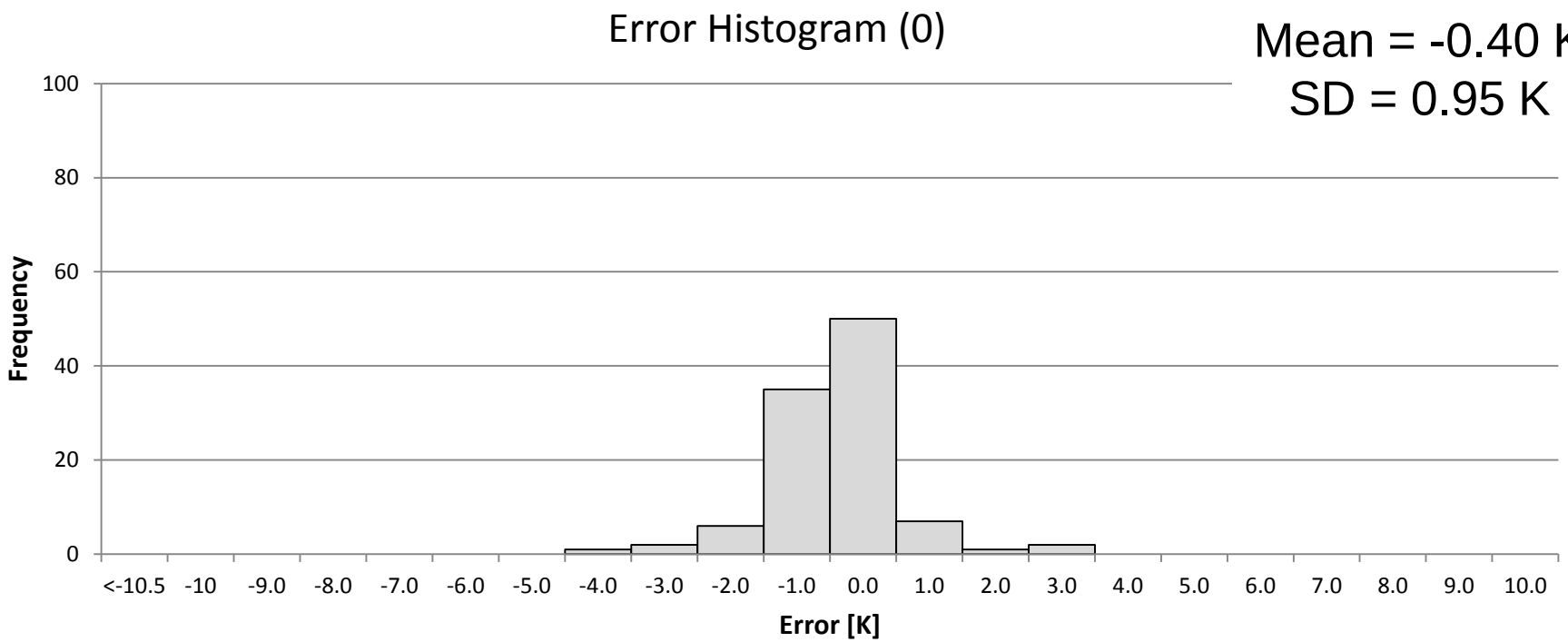
L5 MERRA

153 scenes
39%
Mean = -0.51 K
SD = 1.09 K

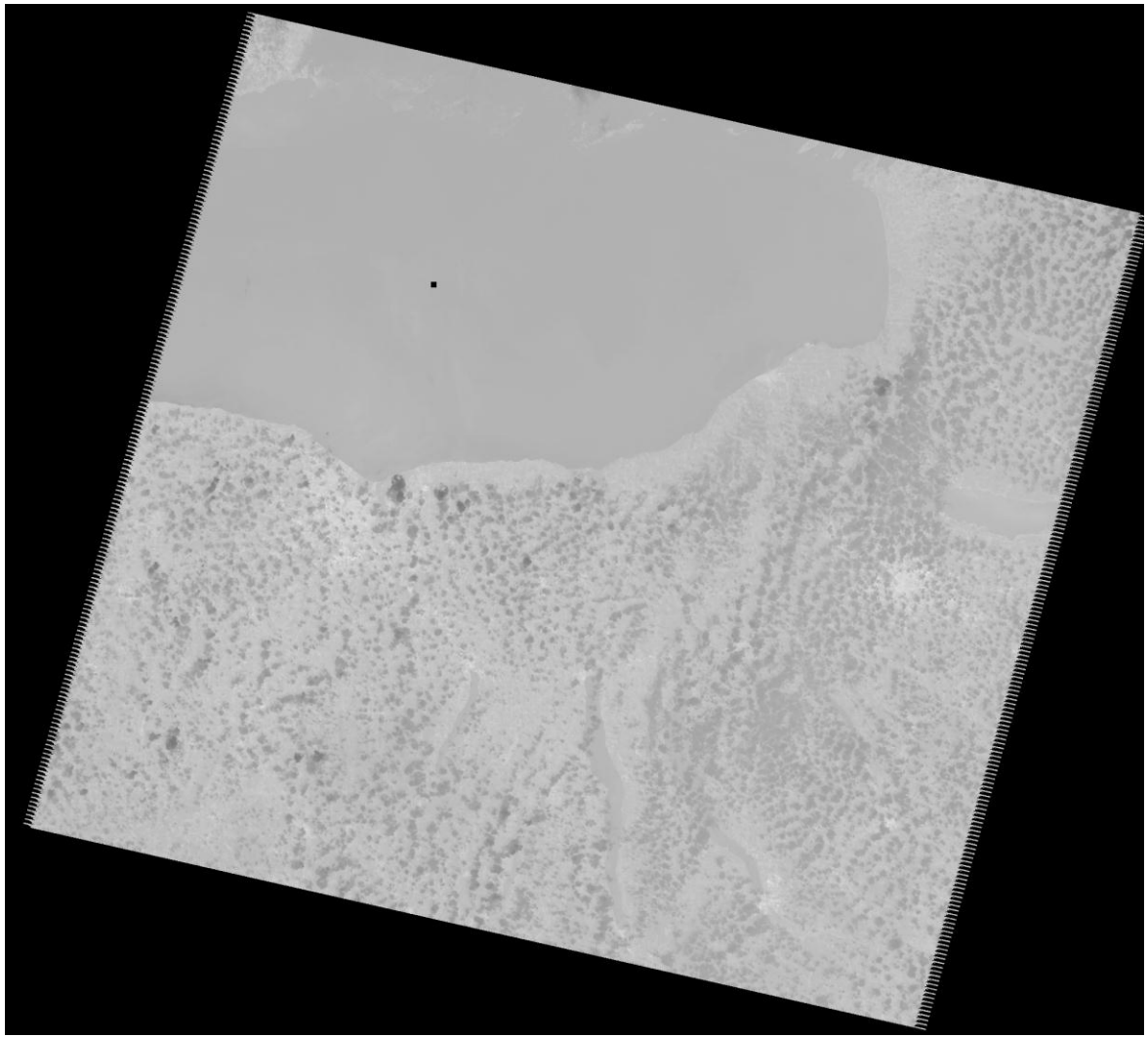


L5 MERRA

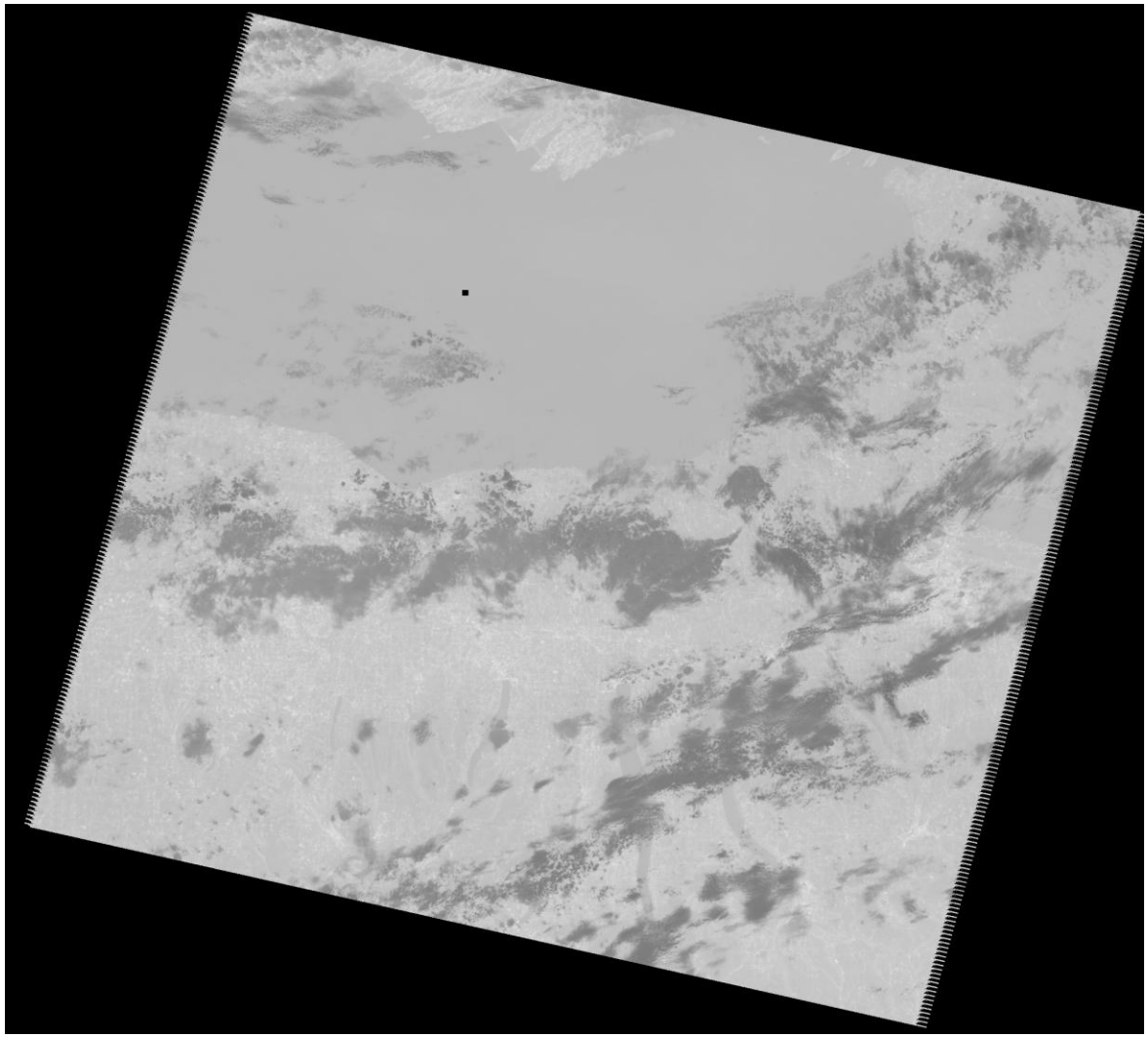
104 scenes
26%
Mean = -0.40 K
SD = 0.95 K



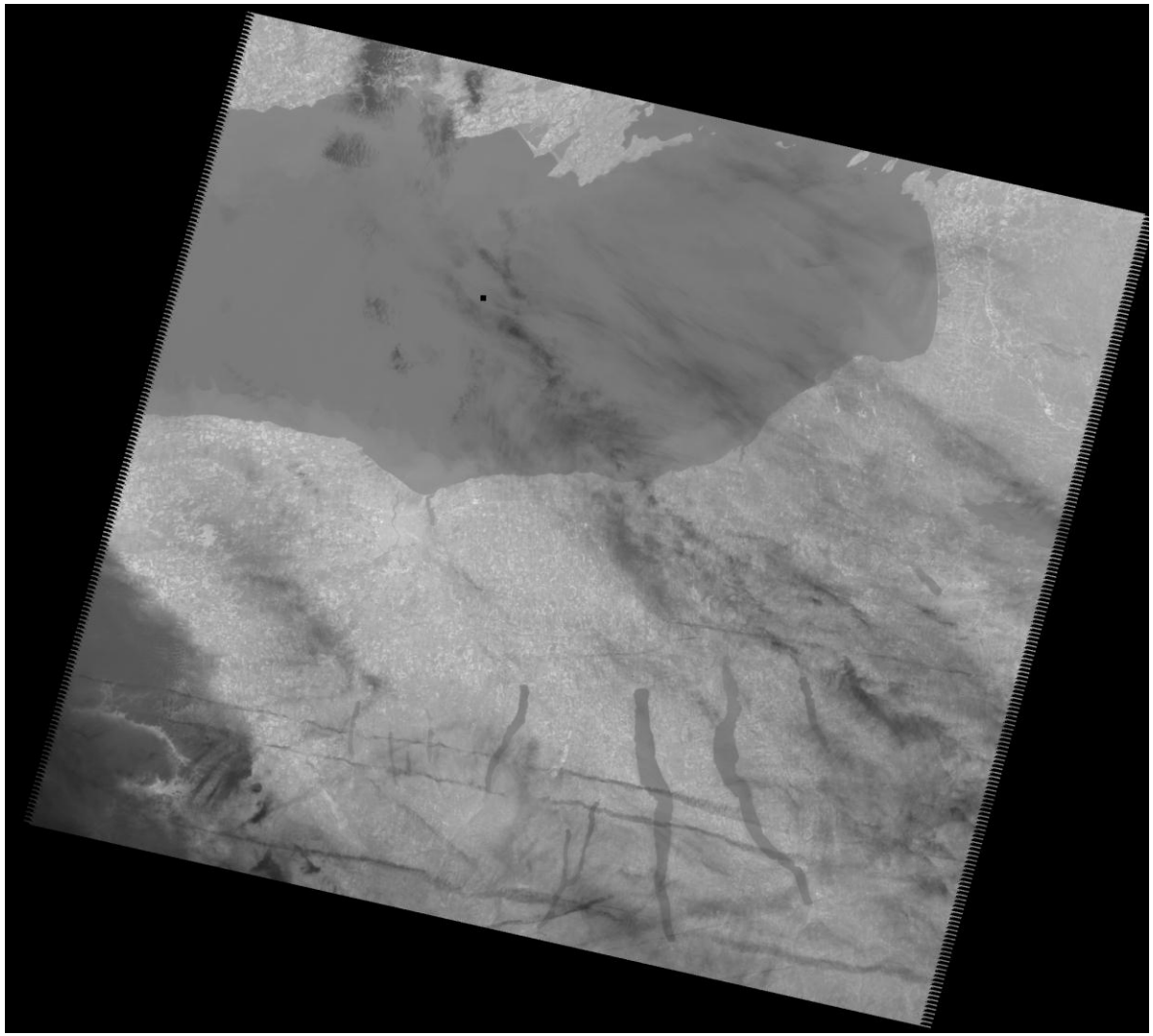
Cloud Screening - 0



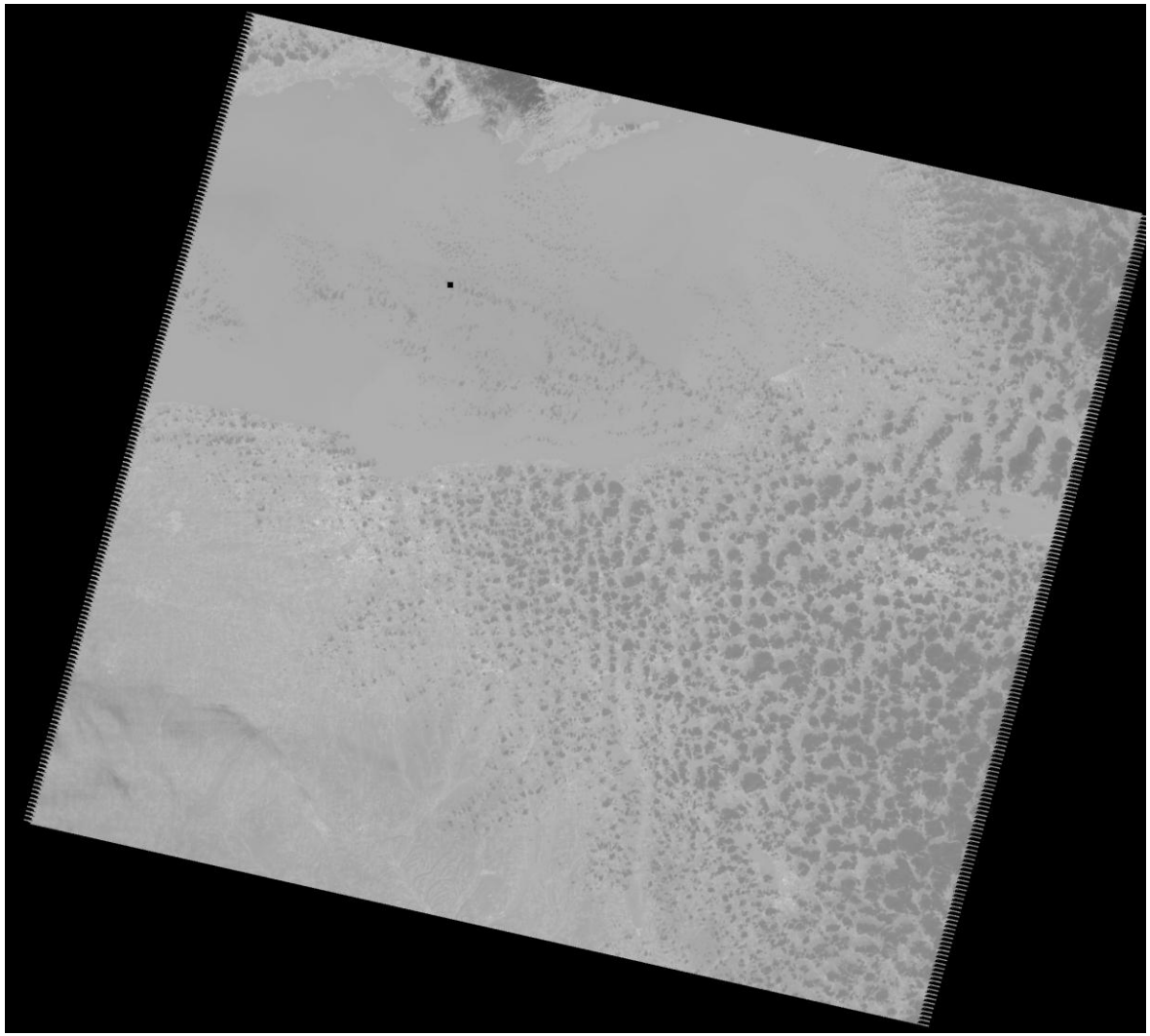
Cloud Screening - 1



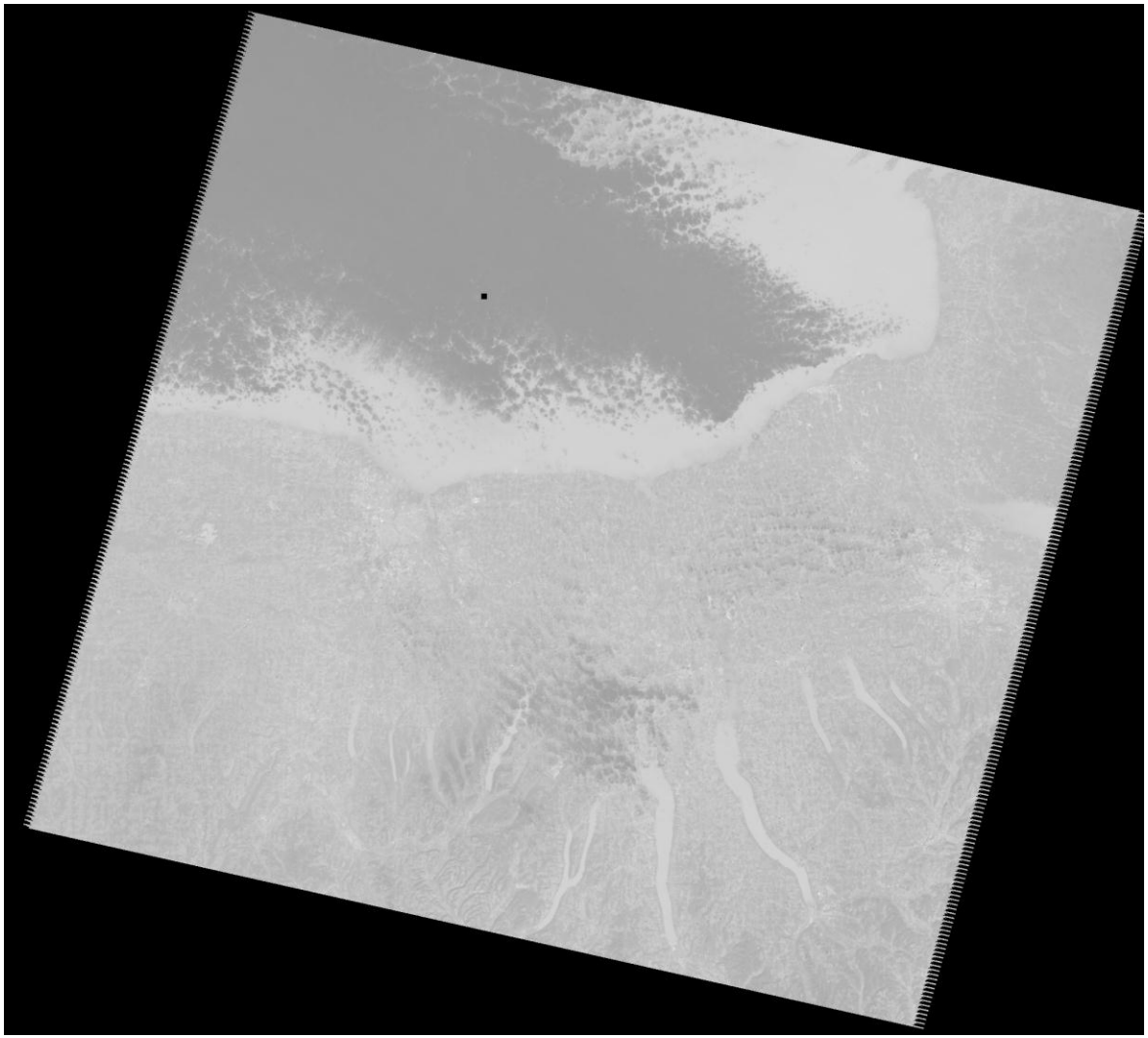
Cloud Screening - 2



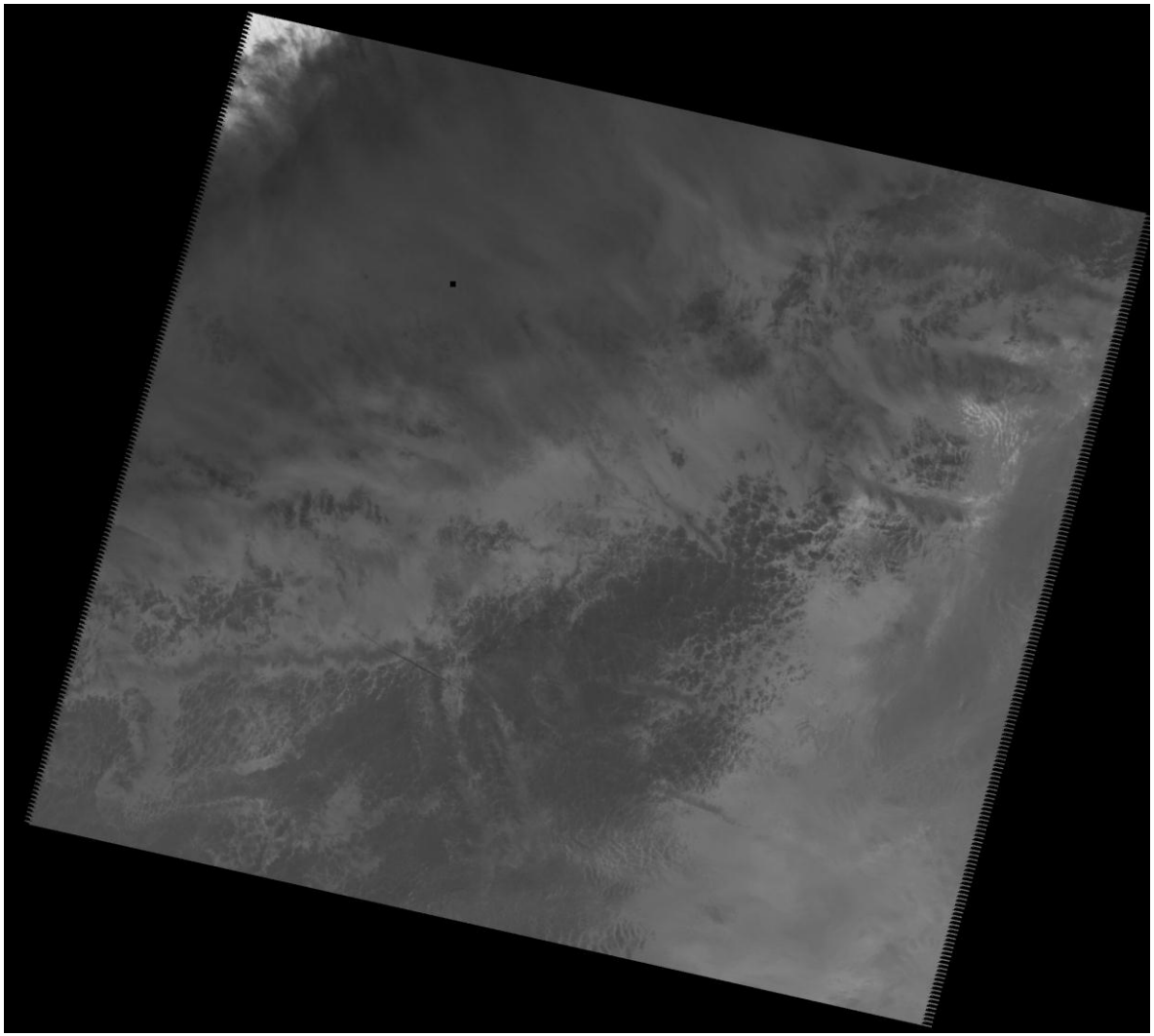
Cloud Screening - 3



Cloud Screening - 4



Cloud Screening - 5



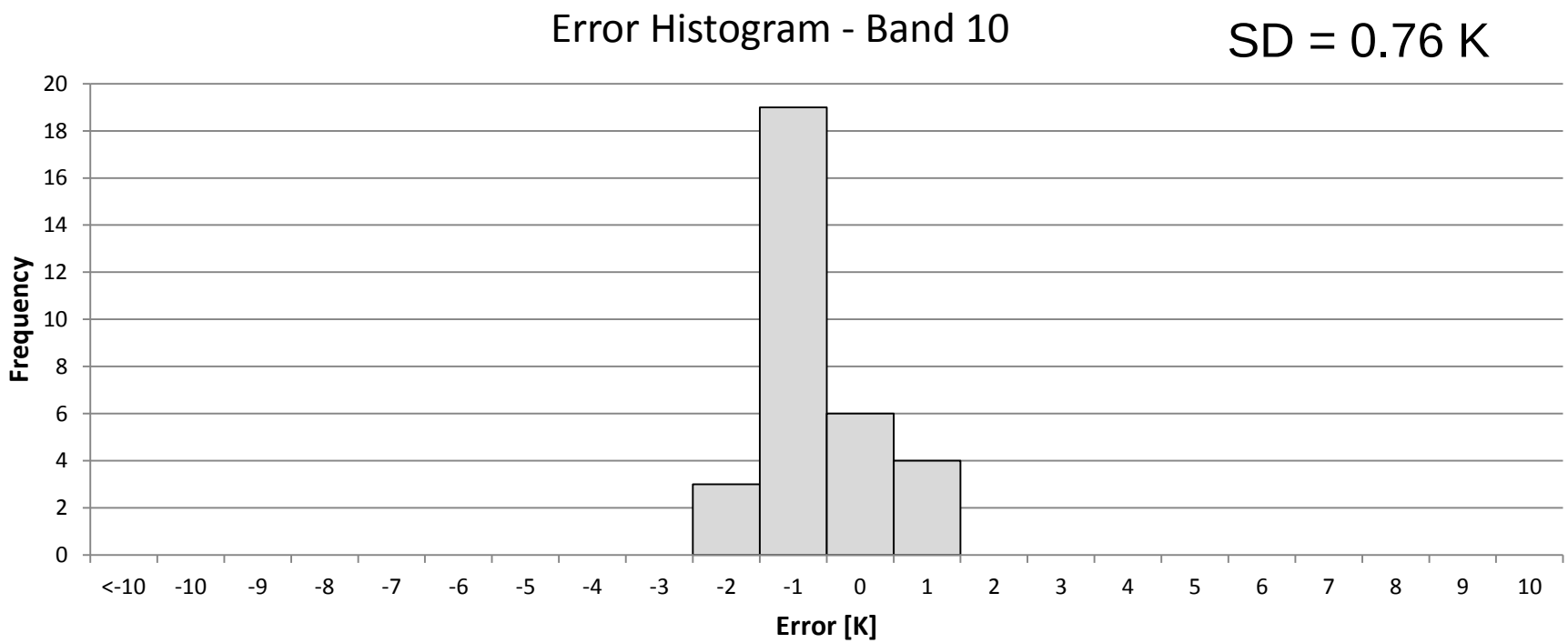
Compare Validation

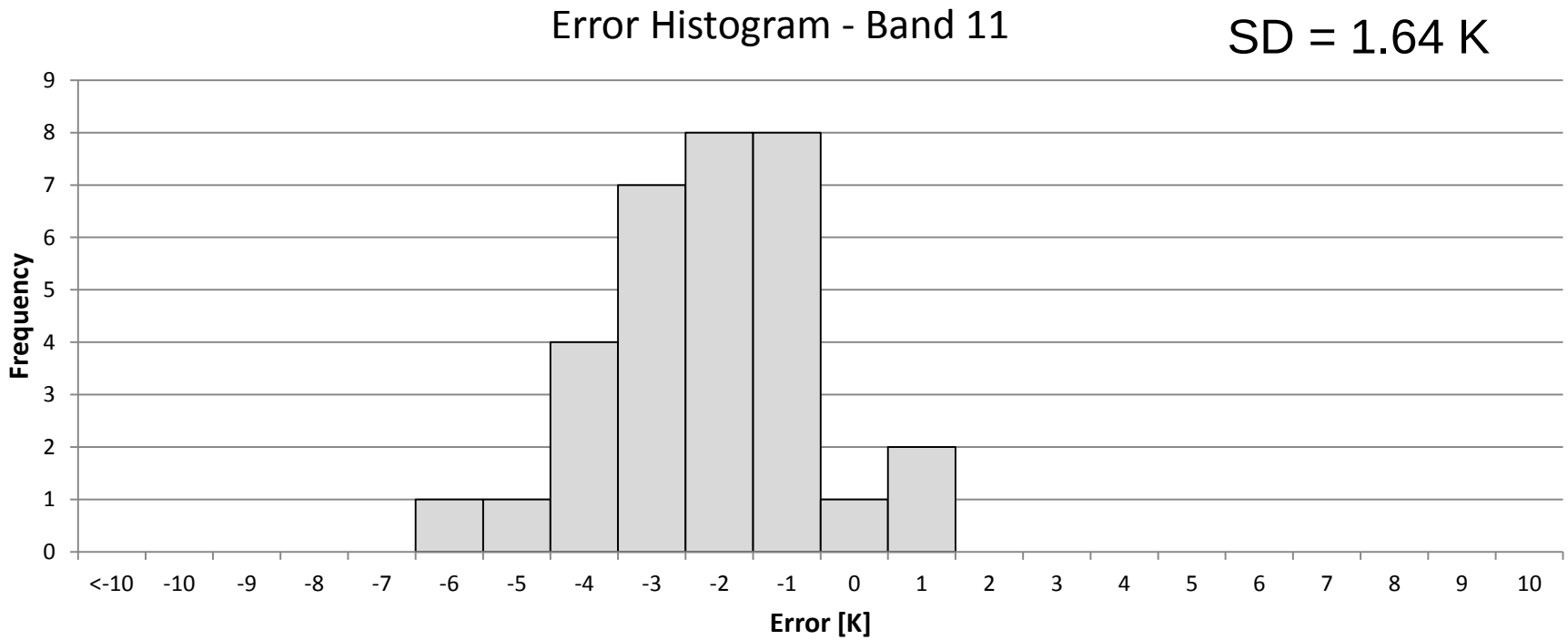
- Comparison for the same dataset (397 scenes)

	MERRA	NARR	MERRA	NARR
Cloud	**Mean**	**Mean**	**SD**	**SD**
0,1,2,3,4,5	-8.697	-8.470	18.52	18.19
0,1,2,3	-1.474	-1.446	3.61	3.72
0,1,2	-0.954	-1.002	1.85	2.14
0,1	-0.513	-0.441	1.09	1.47
0	-0.398	-0.235	0.95	0.92

L8 Band 10 NARR

32 scenes
Mean = -0.56 K
SD = 0.76 K



L8 Band 11 NARR

32 scenes
Mean = -2.16 K
SD = 1.64 K