# VIIRS LST Calibration/Validation: Progress and Issues

Ming Chen, Bob Yu and Dan Tarpley
Jan 05, 2010

## 1. Current Status

- Synthetic 1km-pixel data sets were generated from the ASTER 90m TIR data. There are 9 different synthetic pixels for each SURFRAD site (**Figure1**). Each synthetic pixel has the SURFRAD station covered. The data of each synthetic pixel is the time series of 13X13 ASTER pixel array over years 2000-2007 (**Table 1**).
- Preliminary statistical analysis was performed using the time series data of each synthetic pixel. The results are summarized **Table 2**.
- The potential scaling and angular uncertainties involved in direct site-to-pixel comparisons for VIIR LST cal/val were analyzed.
- Scaling model which would provide pertinent statistical relationship between ground and satellite measurements is under development.

## 2. Analysis Method

- Synthesizing VIIRS pixel with fine-resolution satellite pixels. The synthesized pixel is expected to retain sufficient information about the sub-pixel heterogeneity of a VIIR/ABI pixel, and the directional variation of the sub-pixel heterogeneity. ONLY the case where all the 9 synthetic pixels are clear was picked up for analysis.
- Aggregating the fine-resolution satellite pixels to VIIR pixel by proper scaling models. So far, we use simple average (of the sub pixels) for a synthetic pixel value.
- Calculating SURFRAD LST from upward and downward long wave radiations.
- Comparing SURFRAD LST with synthetic pixel LST and evaluating the uncertainties involved. The comparison was performed among the following **time series**:

  Tsurf (or Ts): surfrad LST
  Tavg (or Ta): average LST of the 13X13 ASTER pixel array
  Tcnt (or Tc): LST of the ASTER pixel nearest to the ground site

  *Note: For each clear case (or an instance), we have such a triplet. And over 2000-2007, we have the time series of such triplets.*

## 3. Summary of the analysis results

- The mean difference between SURFRAD LST and synthetic LST is generally around 1K and the standard deviation of such difference is around 2K. See **Tables 1-4.** Desert Rock station has largest mean difference (Ts-Ta).

- In terms of Tc-Ta, i.e., the mean difference between central ASTER pixel and the synthetic pixel, directional variation of the potential sub-pixel heterogeneity is found to be consistent with the physical topographic features. **Figures 2-4** show such consistency at Desert Rock station and Bondville station.

- The standard deviation of Tc-Ta is around 1K. This statistic variable deserves more investigation. In general, one should not expect large standard deviation of Tc-Ta **IF** the site is "smooth" enough. Large standard deviation of Tc-Ta may indicate that the simple aggregation method (scale model) is not suitable for the evaluation of the synthetic mean. Except the physical sub-pixel heterogeneities, such as land cover, orography, sub-pixel cloud contamination may bring about another kind of heterogeneity from instance to instance.

- The limited datasets doesn't allow us to characterize the seasonal variation of heterogeneities, which is more desirable than a simple mean difference. More datasets are expected.

## 4. Issues and Plan

- Data limitation issues:
    a) The limited data made it impossible to perform fine analysis over time scales of interest, e.g., seasonal variation. More data over SURFRAD sites is needed.
    b) Datasets over CRN sites
- Statistic variables pertinent for site representativeness analysis
- Up/down-scaling models
- SURFRAD emissivity

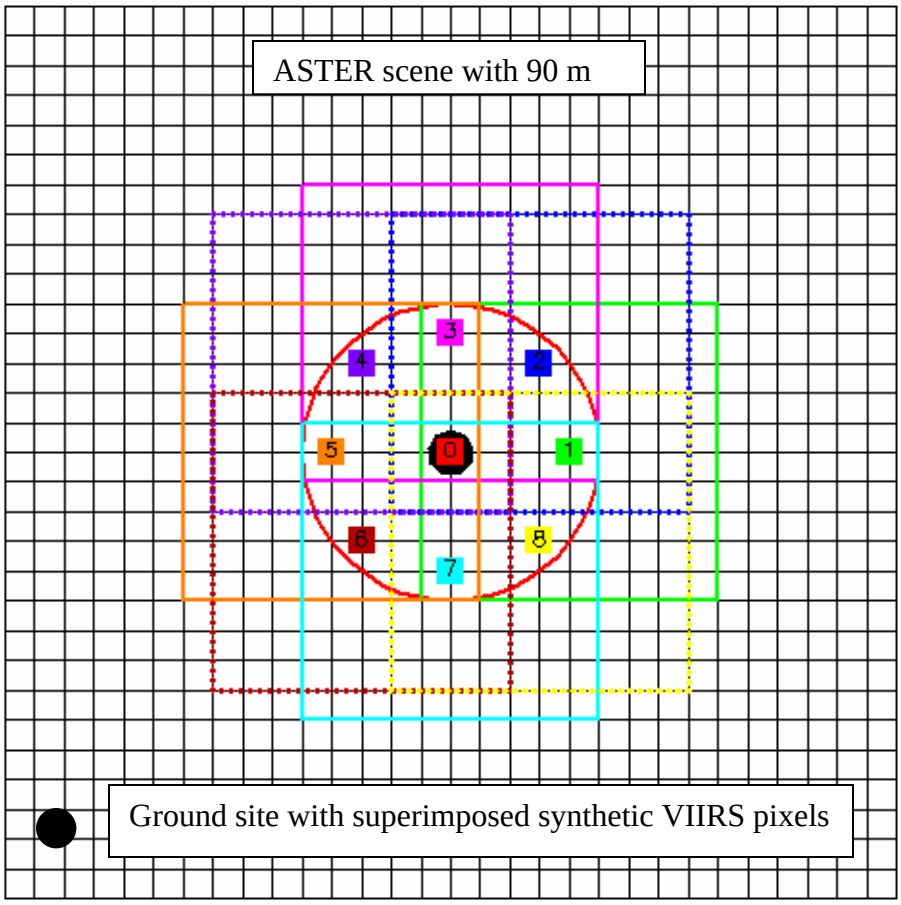


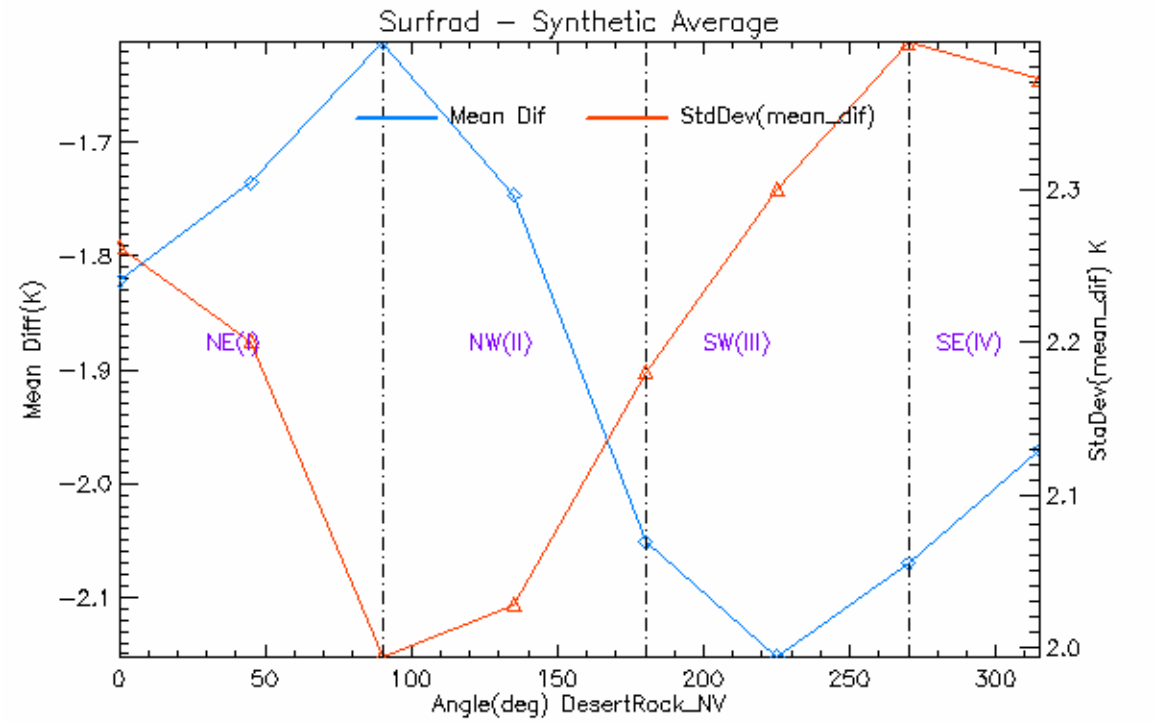

**Figure 1.** This figure shows how a set of nine synthetic pixels to composed from fine-resolution (90m) ASTER TIR pixels. Each synthetic pixel has the target ground site enclosed, but the distance between the ground site and the center of synthetic pixel varies, which mimics the possible over-passing VIIRS swaths. Nevertheless, the distance of every synthetic pixel center from the ground site is within the pixel size (1Km). Different colors are used for the 9 synthetic pixels, and the center of each pixel is marked with a small numbered square of the same corresponding color. The numbers on the squares are the pixel IDs used in the relevant analysis.

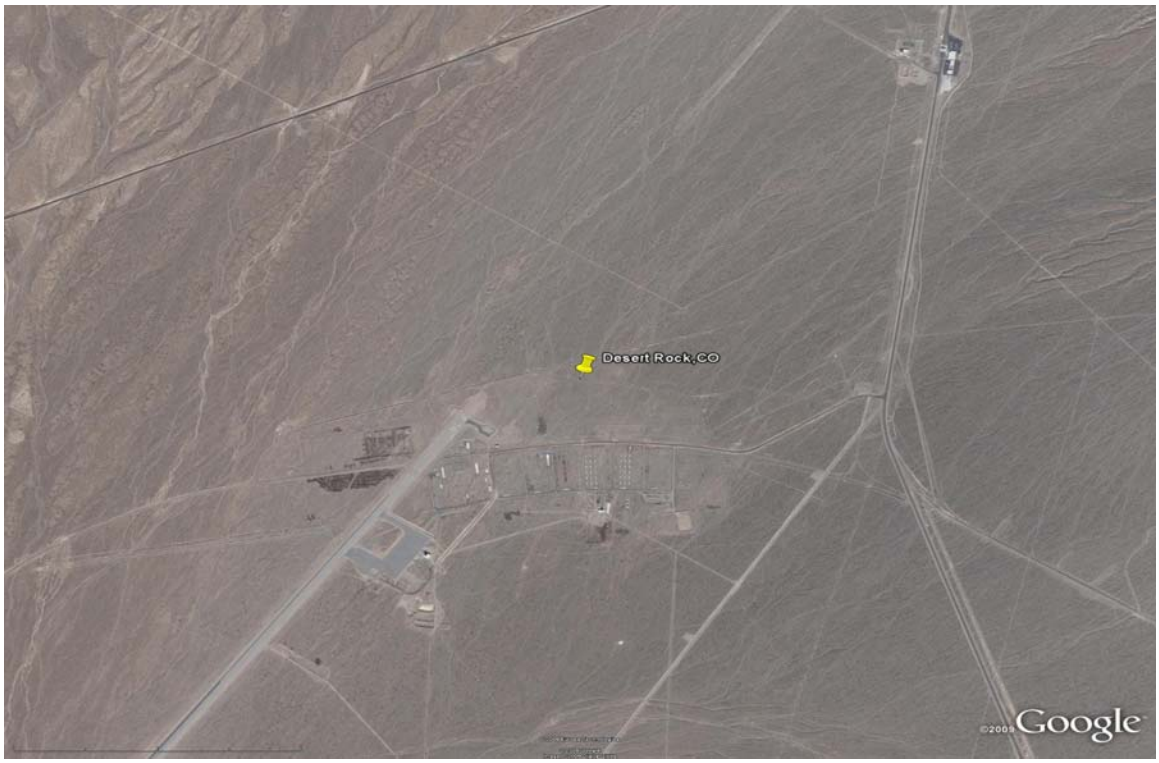
**Table 1. ASTER and SURFRAD Data**

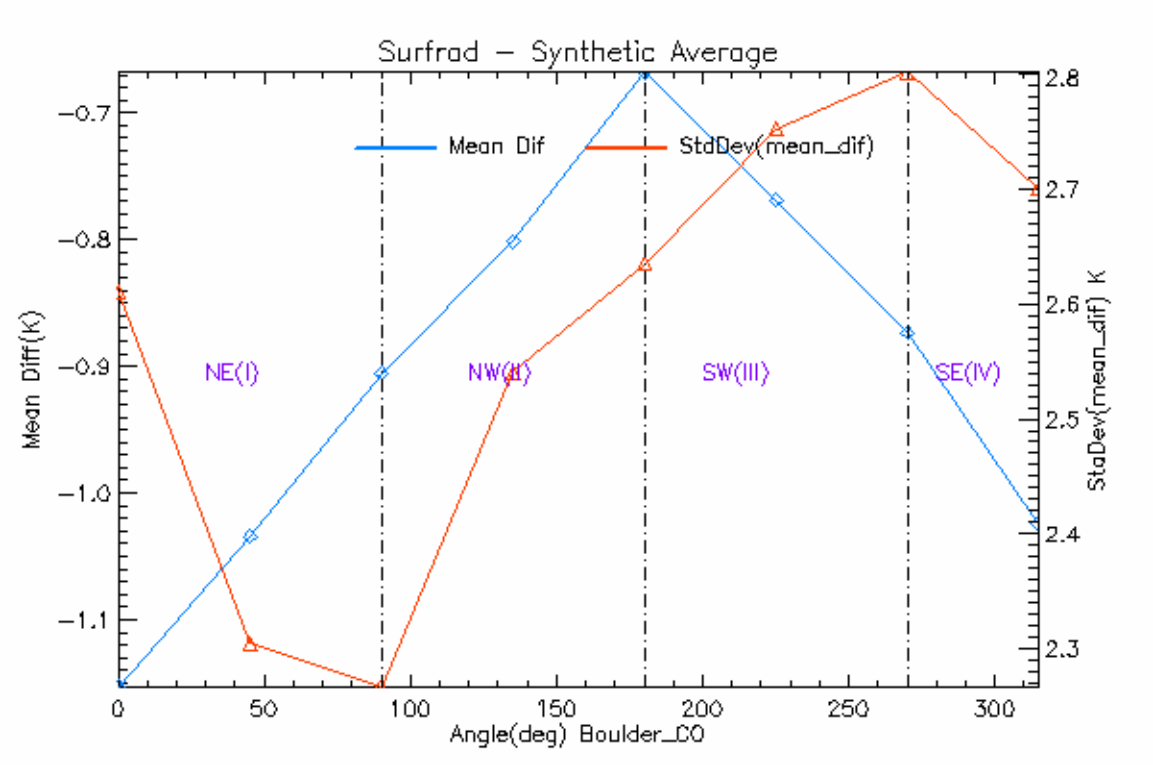
- Data period: **2000 – 2007**
- SURFRAD stations characterized so far

| Stations | Clear Cases By ASTER Cloud masks | Clear Cases By Augmented Screening |
|---|---|---|
| Desert Rock, Co | 63 | 46 |
| Bondville, IL | 115 | 51 |
| PennState,PA | 61 | 20 |
| Boulder, CO | 35 | 13 |
| Fort Peck, MT | 12 | 8 |

**Figures 2-4**


Surfrad – Synthetic Average
Mean Dif
StdDev(mean_dif)
Mean Diff(K)
StaDev(mean_dif) K
NE(I)
NW(II)
SW(III)
SE(IV)
−1.7
−1.8
−1.9
−2.0
−2.1
2.3
2.2
2.1
2.0
0
50
100
150
200
250
300
Angle(deg) DesertRock_NV


Desert Rock,CO
Google


Surfrad – Synthetic Average
Mean Dif
StdDev(mean_dif)
NE(I)
NW(II)
SW(III)
SE(IV)
Mean Diff(K)
StdDev(mean_dif) K
Angle(deg) Boulder_CO
−0.7
−0.8
−0.9
−1.0
−1.1
2.8
2.7
2.6
2.5
2.4
2.3
0
50
100
150
200
250
300

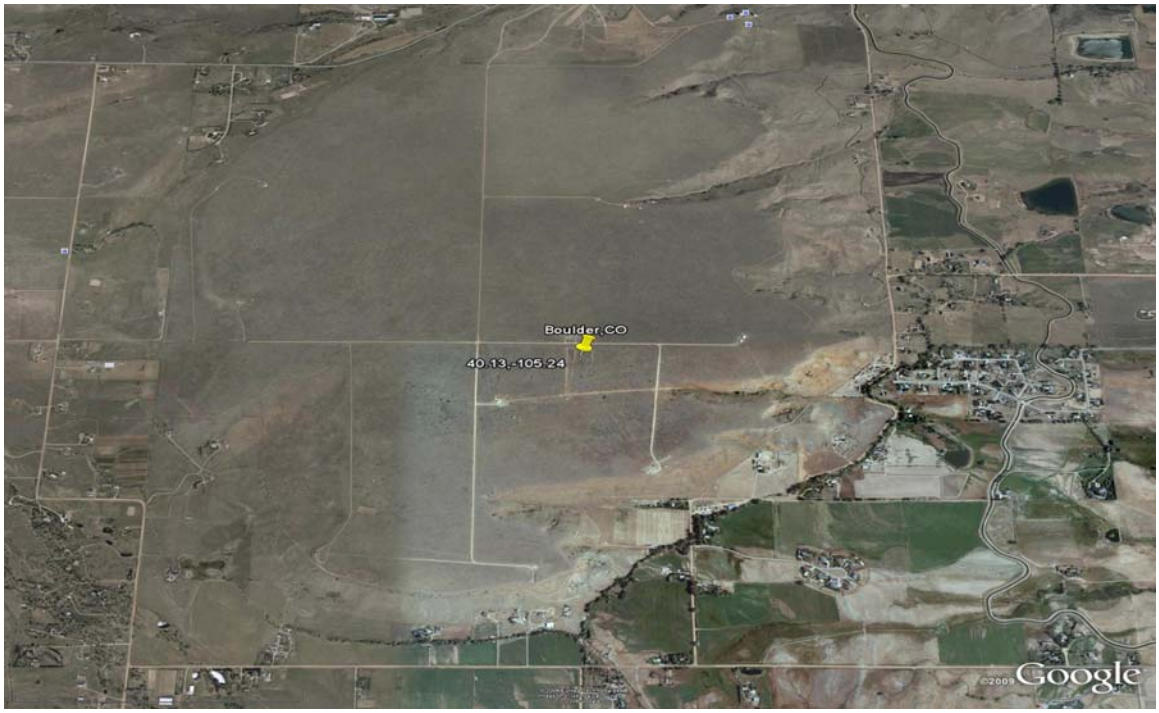

Boulder,CO
40.13,-105.24
Google

**Table 2. Summary of synthetic pixel analysis**

** the values listed in the tables are time series statistics of the triplets, i.e., evaluated over time space.*

## 1. Desert Rock, NV

| Pixel ID | Deg | Tsurf | Tcnt | Tavg | Mean (Ts-Ta) | StdDev (Ts-Ta) | Mean (Tc-Ta) | StdDev (Tc-Ta) | Mean (Ts-Tc) | StdDev (Ts-Tc) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 310.3 | 312.12 | 312.08 | -1.78 | 2.13 | 0.04 | 0.69 | -1.81 | 2.46 |
| 1 | 0 | 310.3 | 312.12 | 312.13 | -1.82 | 2.26 | -0.01 | 0.60 | -1.81 | 2.46 |
| 2 | 45 | 310.3 | 312.12 | 312.04 | -1.74 | 2.20 | 0.08 | 0.61 | -1.81 | 2.46 |
| 3 | 90 | 310.3 | 312.12 | 311.92 | -1.61 | 1.99 | 0.20 | 0.92 | -1.81 | 2.46 |
| 4 | 135 | 310.3 | 312.12 | 312.05 | -1.75 | 2.03 | 0.06 | 0.96 | -1.81 | 2.46 |
| 5 | 180 | 310.3 | 312.12 | 312.36 | -2.05 | 2.18 | -0.24 | 0.98 | -1.81 | 2.46 |
| 6 | 225 | 310.3 | 312.12 | 312.46 | -2.15 | 2.30 | -0.34 | 0.80 | -1.81 | 2.46 |
| 7 | 270 | 310.3 | 312.12 | 312.37 | -2.07 | 2.40 | -0.26 | 0.65 | -1.81 | 2.46 |
| 8 | 315 | 310.3 | 312.12 | 312.27 | -1.97 | 2.37 | -0.16 | 0.60 | -1.81 | 2.46 |
| Average | | 310.3 | 312.12 | 312.19 | -1.88 | 2.21 | -0.07 | 0.76 | -1.81 | 2.46 |

## 2. Boulder, CO

| Pixel ID | Deg | Tsurf | Tcnt | Tavg | Mean (Ts-Ta) | StdDev (Ts-Ta) | Mean (Tc-Ta) | StdDev (Tc-Ta) | Mean (Ts-Tc) | StdDev (Ts-Tc) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 288.12 | 288.89 | 288.96 | -0.84 | 2.62 | -0.07 | 0.58 | -0.77 | 2.6 |
| 1 | 0 | 288.12 | 288.89 | 289.28 | -1.15 | 2.61 | -0.38 | 0.85 | -0.77 | 2.6 |
| 2 | 45 | 288.12 | 288.89 | 289.16 | -1.03 | 2.3 | -0.27 | 0.91 | -0.77 | 2.6 |
| 3 | 90 | 288.12 | 288.89 | 289.03 | -0.91 | 2.27 | -0.14 | 0.84 | -0.77 | 2.6 |
| 4 | 135 | 288.12 | 288.89 | 288.92 | -0.80 | 2.54 | -0.03 | 0.61 | -0.77 | 2.6 |
| 5 | 180 | 288.12 | 288.89 | 288.79 | -0.67 | 2.64 | 0.10 | 0.61 | -0.77 | 2.6 |
| 6 | 225 | 288.12 | 288.89 | 288.89 | -0.77 | 2.75 | 0.00 | 0.69 | -0.77 | 2.6 |
| 7 | 270 | 288.12 | 288.89 | 289.00 | -0.87 | 2.80 | -0.10 | 0.70 | -0.77 | 2.6 |
| 8 | 315 | 288.12 | 288.89 | 289.15 | -1.02 | 2.70 | -0.25 | 0.70 | -0.77 | 2.6 |
| Average | | 288.12 | 288.89 | 289.02 | -0.90 | 2.58 | -0.13 | 0.72 | -0.77 | 2.6 |

## 3. Bondville, IL

| Pixel ID | Deg | Tsurf | Tcnt | Tavg | Mean (Ts-Ta) | StdDev (Ts-Ta) | Mean (Tc-Ta) | StdDev (Tc-Ta) | Mean (Ts-Tc) | StdDev (Ts-Tc) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 278.82 | 279.41 | 279.48 | -0.66 | 2.04 | -0.07 | 0.92 | -0.59 | 2.01 |
| 1 | 0 | 278.82 | 279.41 | 279.54 | -0.73 | 2.01 | -0.14 | 1.04 | -0.59 | 2.01 |
| 2 | 45 | 278.82 | 279.41 | 279.46 | -0.64 | 2.05 | -0.05 | 1.07 | -0.59 | 2.01 |
| 3 | 90 | 278.82 | 279.41 | 279.45 | -0.64 | 2.17 | -0.05 | 1.27 | -0.59 | 2.01 |
| 4 | 135 | 278.82 | 279.41 | 279.49 | -0.68 | 2.10 | -0.09 | 1.15 | -0.59 | 2.01 |
| 5 | 180 | 278.82 | 279.41 | 279.42 | -0.60 | 2.14 | -0.01 | 1.10 | -0.59 | 2.01 |
| 6 | 225 | 278.82 | 279.41 | 279.44 | -0.62 | 2.12 | -0.03 | 0.97 | -0.59 | 2.01 |
| 7 | 270 | 278.82 | 279.41 | 279.59 | -0.77 | 2.05 | -0.18 | 0.95 | -0.59 | 2.01 |
| 8 | 315 | 278.82 | 279.41 | 279.62 | -0.80 | 2.02 | -0.21 | 0.97 | -0.59 | 2.01 |

| Average | 278.82 | 279.41 | 279.5 | -0.68 | 2.08 | -0.09 | 1.05 | -0.59 | 2.01 |
|---|---|---|---|---|---|---|---|---|---|

## 4. Penn State, PA

| Pixel ID | Deg | Tsurf | Tcnt | Tavg | Mean (Ts-Ta) | StdDev (Ts-Ta) | Mean (Tc-Ta) | StdDev (Tc-Ta) | Mean (Ts-Tc) | StdDev (Ts-Tc) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 286.78 | 286.53 | 286.67 | 0.1 | 1.99 | -0.15 | 1.05 | 0.25 | 2.09 |
| 1 | 0 | 286.78 | 286.53 | 286.35 | 0.43 | 1.93 | 0.18 | 1.13 | 0.25 | 2.09 |
| 2 | 45 | 286.78 | 286.53 | 286.37 | 0.41 | 2.07 | 0.15 | 1.36 | 0.25 | 2.09 |
| 3 | 90 | 286.78 | 286.53 | 286.58 | 0.20 | 2.19 | -0.05 | 1.38 | 0.25 | 2.09 |
| 4 | 135 | 286.78 | 286.53 | 286.68 | 0.09 | 1.91 | -0.16 | 1.07 | 0.25 | 2.09 |
| 5 | 180 | 286.78 | 286.53 | 286.67 | 0.10 | 1.96 | -0.15 | 1.14 | 0.25 | 2.09 |
| 6 | 225 | 286.78 | 286.53 | 286.77 | 0.01 | 1.93 | -0.25 | 1.13 | 0.25 | 2.09 |
| 7 | 270 | 286.78 | 286.53 | 286.73 | 0.04 | 1.91 | -0.21 | 1.03 | 0.25 | 2.09 |
| 8 | 315 | 286.78 | 286.53 | 286.59 | 0.19 | 1.98 | -0.06 | 0.99 | 0.25 | 2.09 |
| Average | | 286.78 | 286.53 | 286.60 | 0.17 | 1.99 | -0.08 | 1.14 | 0.25 | 2.09 |