SST Feedback to VIIRS SDR

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with inputs from STAR SST Team

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Summary: VIIRS Performance for SST

Overall, VIIRS is a very good, state of the art sensor for SST

- ✓ Radiances are stable (critical for regression SST)
- ✓ Radiances consistent w/AVHRR/MODIS (critical for physical SST)
- ✓ VIIRS imagery comparable or better than Aqua MODIS
- ✓ VIIRS striping comparable or better than Aqua MODIS

Striping affects SST

- ✓ Striping in VIIRS BTs is within specs. However, it
  - Affects the VIIRS cloud mask and prevents improvements
  - Gets amplified in SST
  - Affects downstream SST products (SST gradients)
- ✓ SST Team works with SDR to reduce striping based on 1st principles
- ✓ Also, SST Team explores destriping in BTs to improve SST EDR

Suggested Improvements

- ✓ Small navigation misalignments are corrected for, for cloud mask
- ✓ Fill in radiances in bow-tie areas. (Currently, filled in with NaNs – suggest put real numbers, while keeping the “bow-tie” flag on)

VIIRS, MODIS, and AVHRR Radiance Monitoring in MICROS

www.star.nesdis.noaa.gov/sod/sst/micros/

Liang, Ignatov: Stability & Radiometric Consistency between AVHRR, MODIS, & VIIRS in SST bands. JGR, Jun 2013.

M-O Biases and Double Differences ("DD")

Model minus Observation ("M-O") Biases

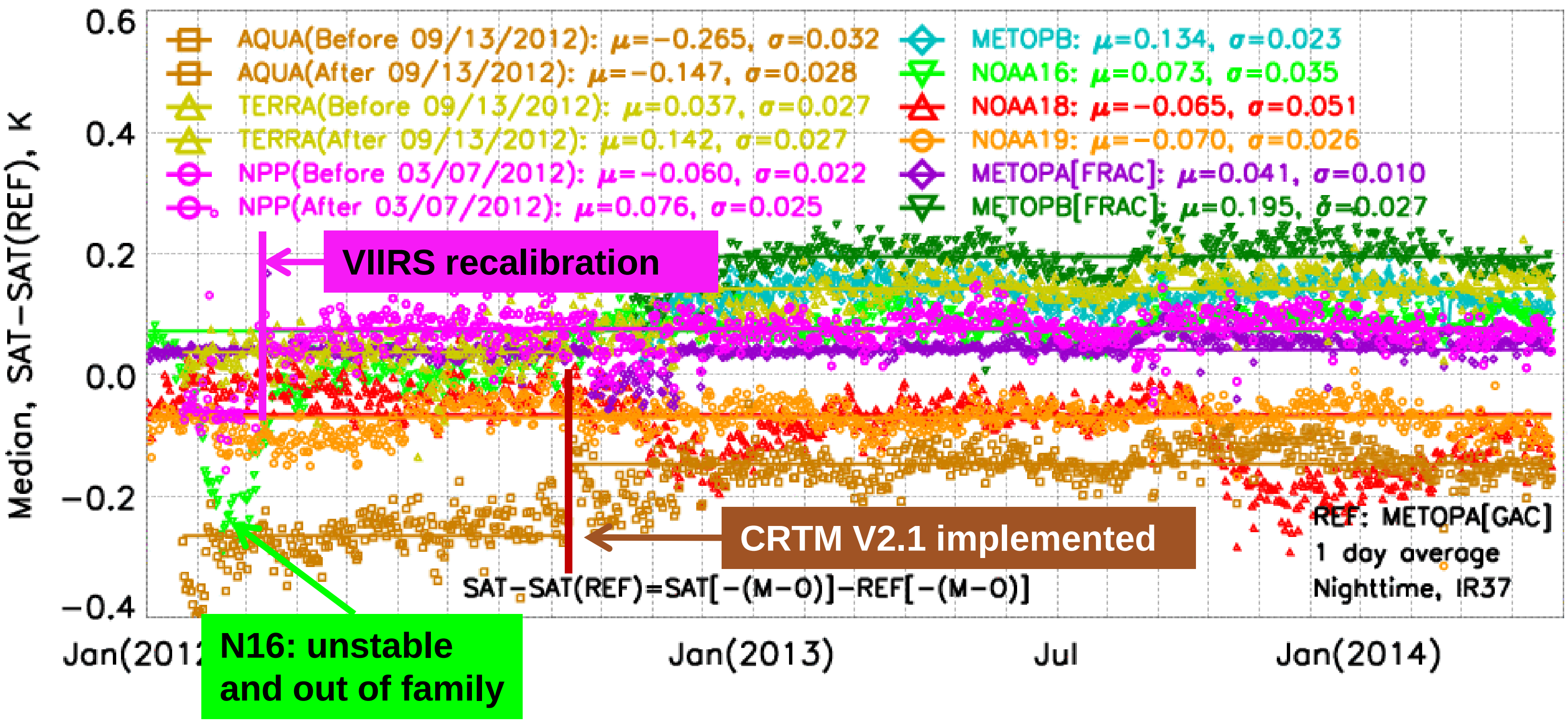
- **M (Model)** = Community Radiative Transfer Model (CRTM) simulated TOA Brightness Temperatures (w/ Reynolds SST, GFS profiles as input)
- **O (Observation)** = Clear-Sky sensor (AVHRR, MODIS, VIIRS) BTs

Double Differences ("DD") for Cross-Platform Consistency

$$SAT - REF = SAT[-(M - O)] - REF[-(M - O)]$$

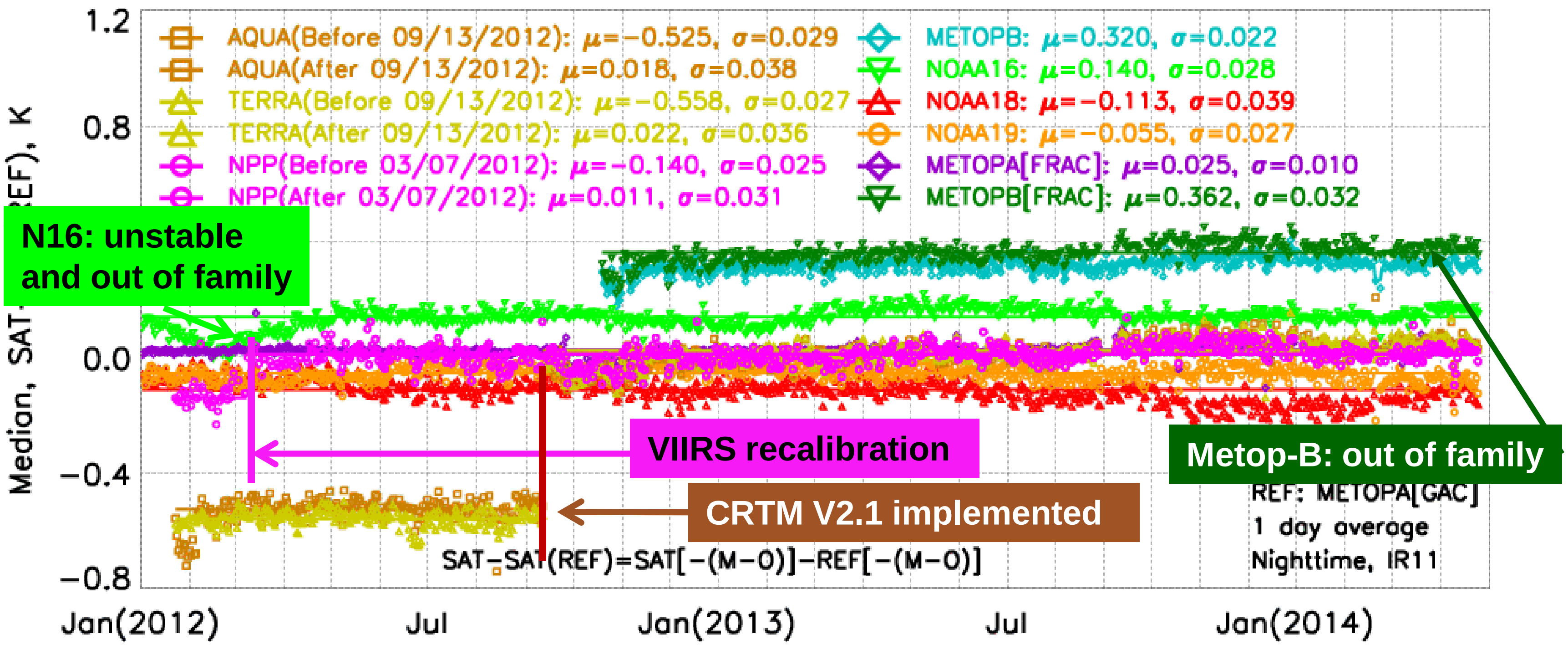
- "M" used as a "Transfer Standard"
- DDs cancel out/minimize effect of systematic errors & instabilities in BTs arising from e.g.
    - Errors/Instabilities in Reynolds SST & GFS
    - Missing aerosol
    - Possible systemic biases in CRTM
    - Updates to ACSPO algorithm

Double Differences in IR37 (VIIRS M12)



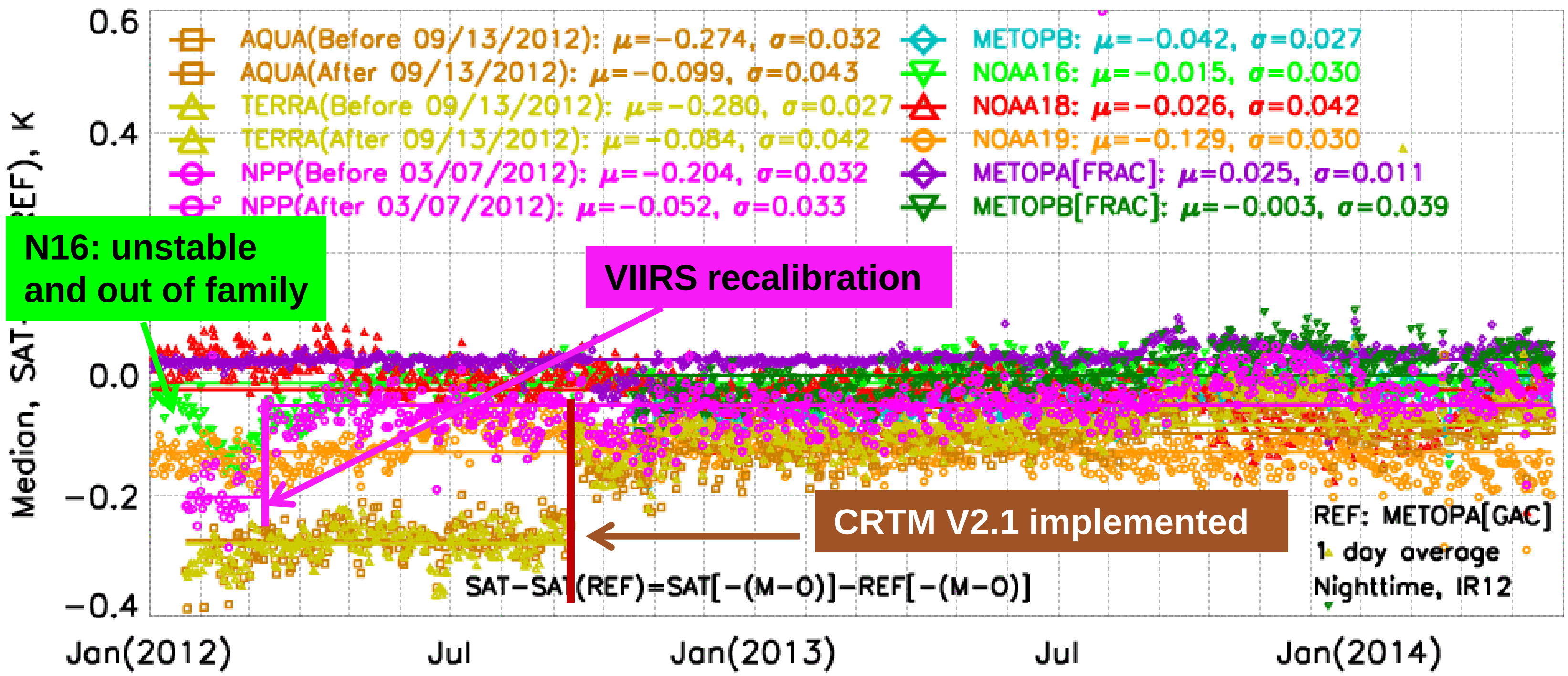
- All sensors are typically within ±0.1K (except Metop-B and Terra/Aqua MODIS)
- VIIRS Cal change 7 Mar 2012 reset BT@M12 by +0.14K – now better in family
- In Sep 2012, CRTM changed from V2.02 to v2.10 – affected DDs (N.B.: No change to sensors BTs)
- CRTM V2.1 implemented 13 Sep 2012: Two MODISs shifted up by 0.1K, better bracket family now
- Metop–B out of family by ~+0.15 K (likely due to suboptimal CRTM coefficients used in CRTM V2.1)

Double Differences in IR11 (VIIRS M15)



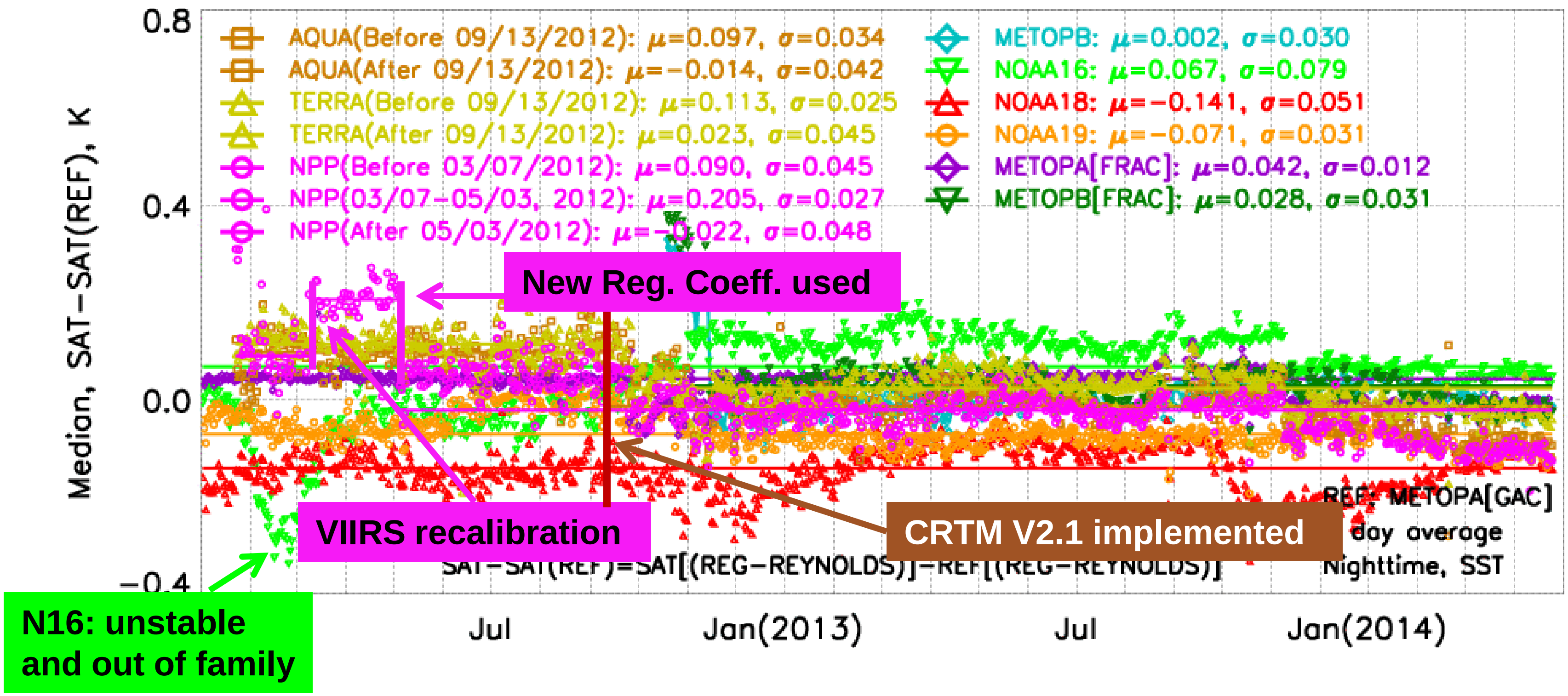
- All AVHRRs (except N16 and Metop-B), MODISs, and VIIRS are now consistent to within ±0.1K
- VIIRS Cal change 7 Mar 2012 reset BT@M15 by +0.14K – now better in family
- Before 13 Sep 2012: Terra & Aqua/MODIS were biased by -0.6K (suboptimal CRTM coeffs in v2.02)
- Both are back in family now, after CRTM V2.1 implemented on 13 Sep 2012
- Metop–B out of family by ~+0.3 K (likely due to suboptimal CRTM coefficients in CRTM V2.1)

Double Differences in IR12 (VIIRS M16)



- All AVHRRs, MODISs, and VIIRS are now consistent to within ±0.1K
- VIIRS Cal change 7 Mar 2012 reset BT@M16 by +0.14K – now better in family
- Terra and Aqua/MODIS were out of family by -0.3K, due to suboptimal CRTM coefficients in V2.02
- Both are back in family now, after CRTM V2.1 implemented on Sep. 13, 2012
- Metop–B in family, but this may change once CRTM coefficients used in CRTM V2.1 are updated

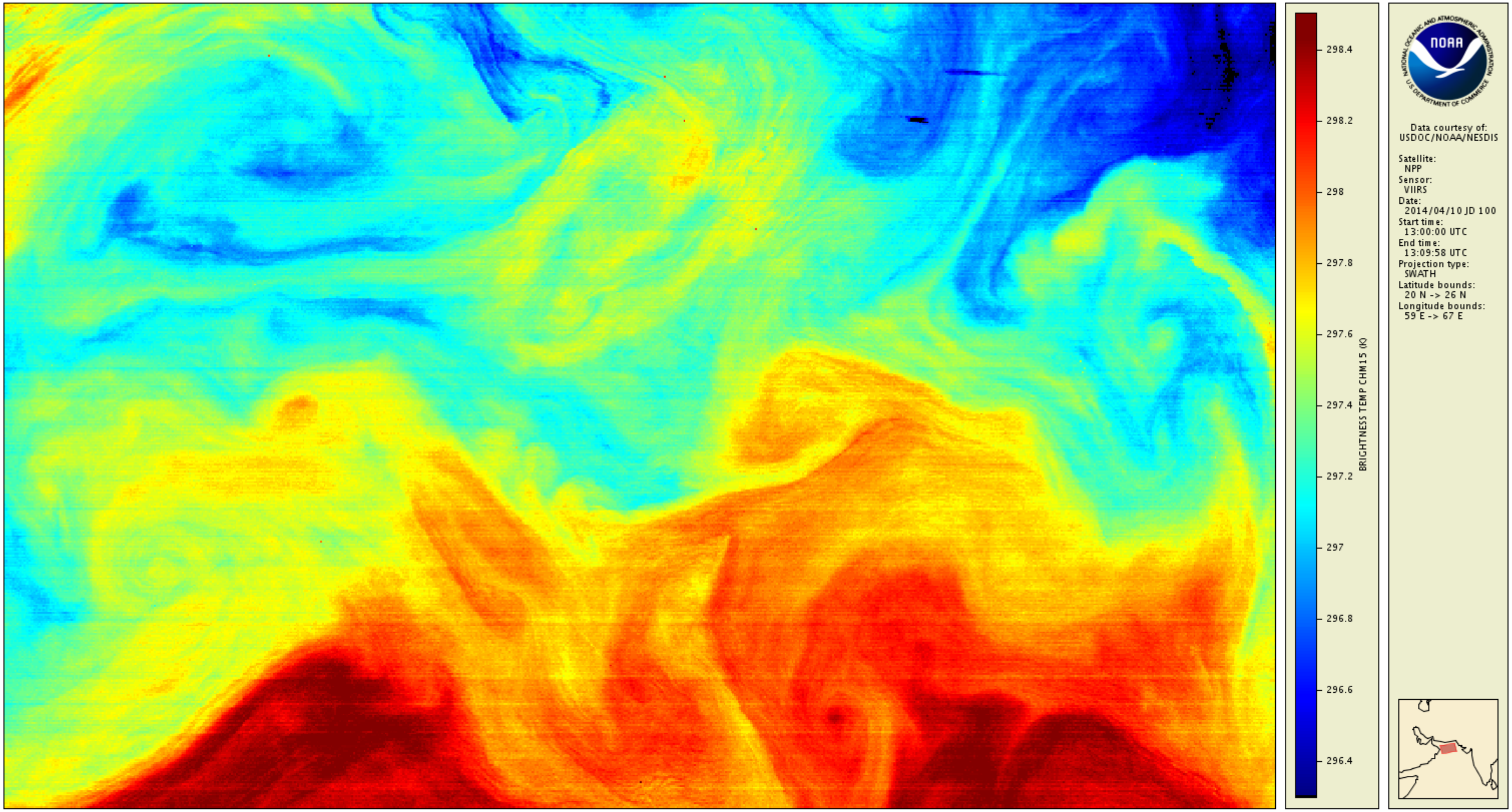
Double Differences in SST



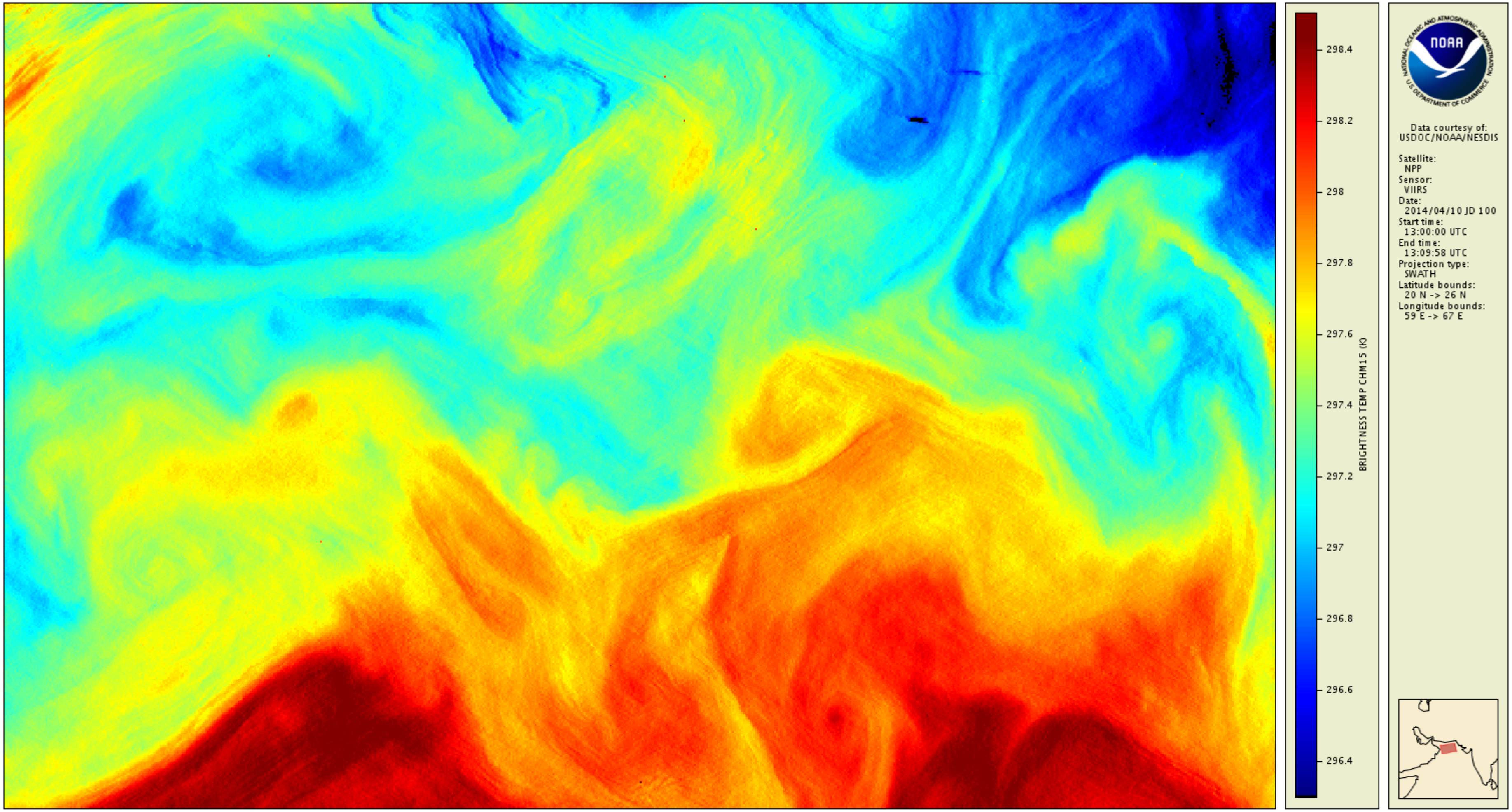
- All AVHRRs, MODISs and NPP/VIIRS SSTs are consistent to within ±0.1K
- As a result of VIIRS Cal Change on 7 Mar 2012, VIIRS SST went out of family
- Was brought back in family when new SST coefficients implemented 3 May 2012
- CRTM update resulted regression SSTs more noise, and the new coefficients have been implemented since Dec. 2012. More data is needed to understand their performance

Effect of VIIRS Striping on SST

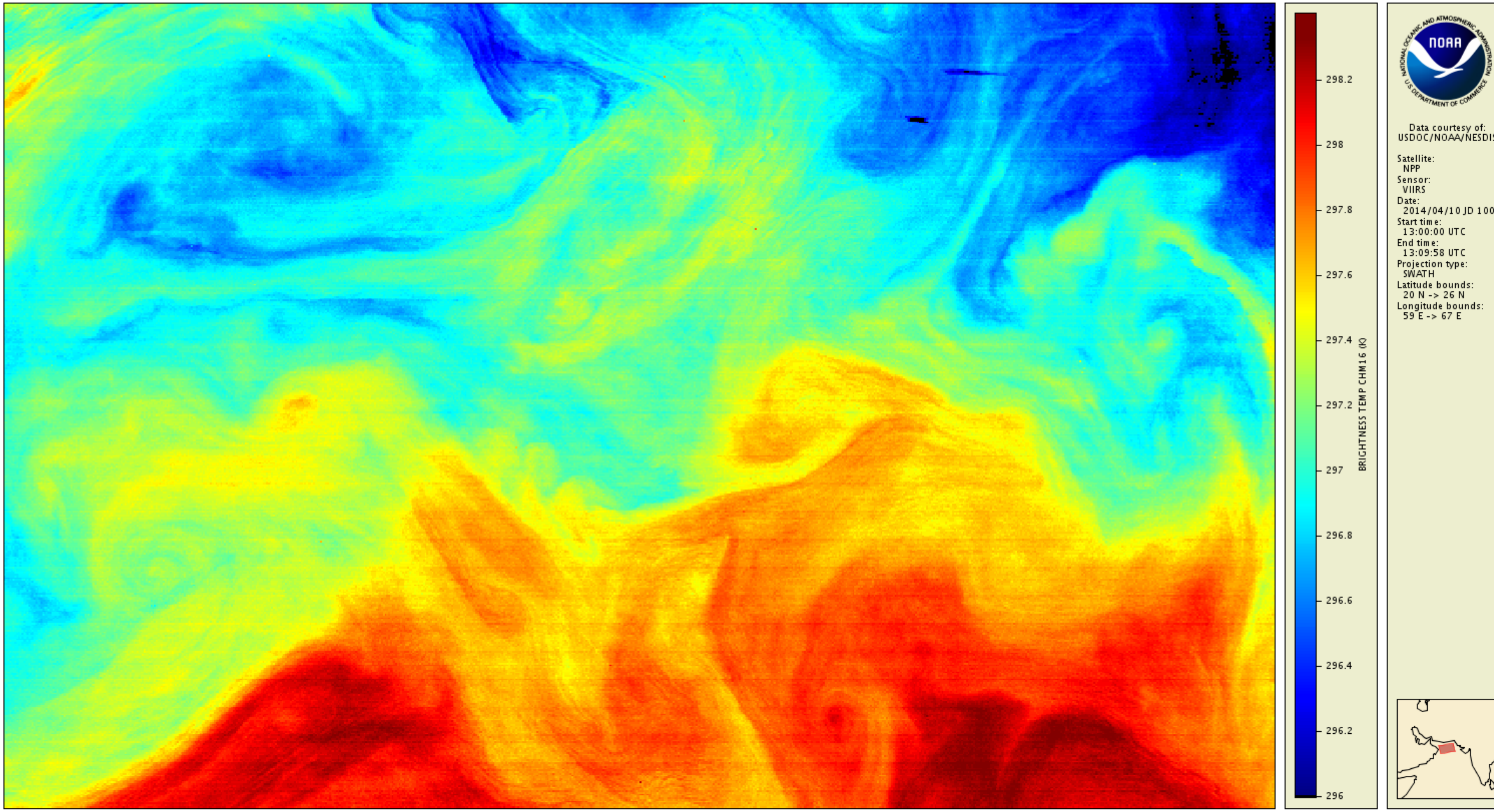
DAY – Original BT in VIIRS band M15 (10.8μm)



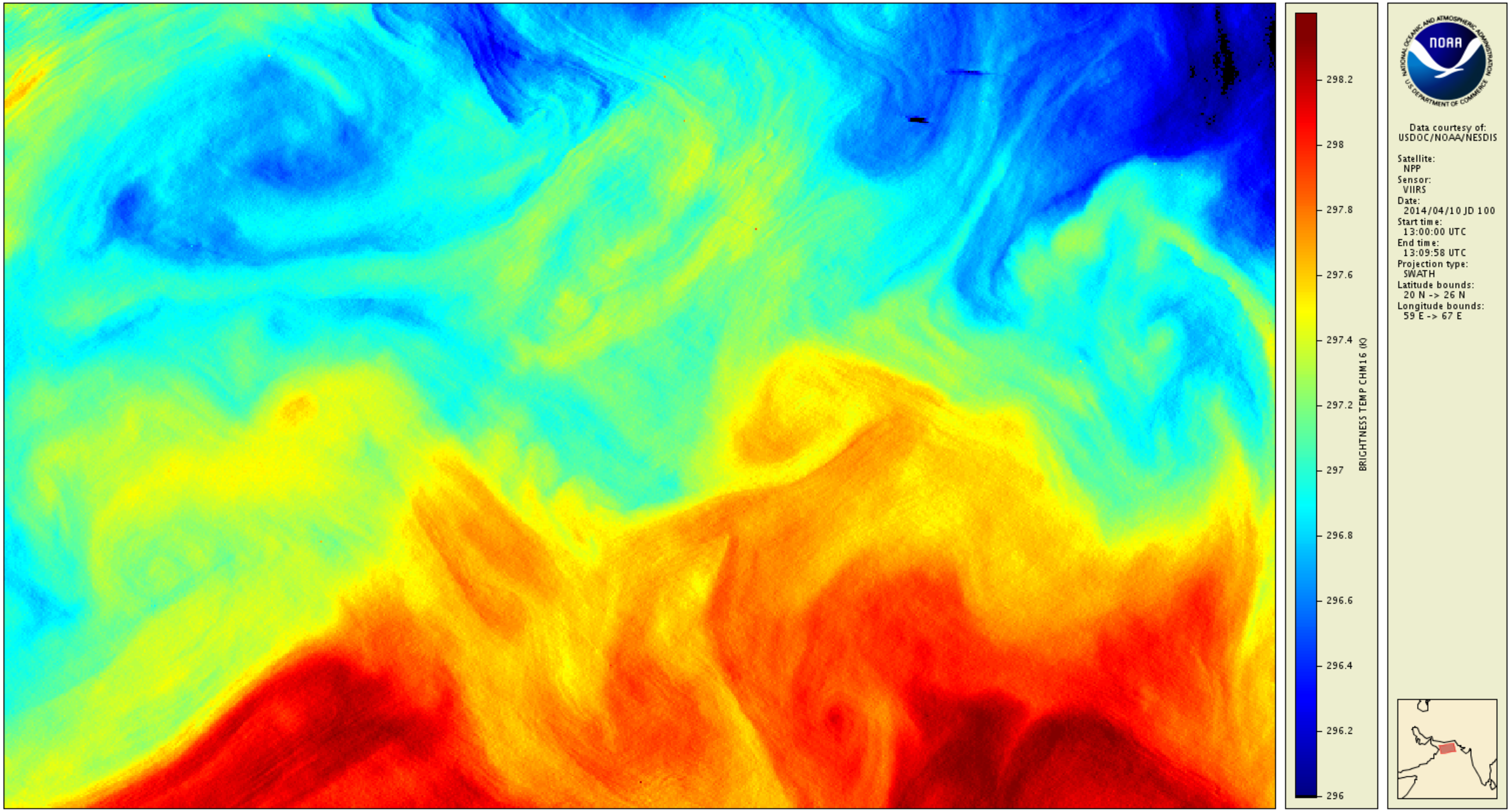
DAY – Destriped BT in VIIRS band M15 (10.8μm)



DAY – Original BT in VIIRS band M16 (12μm)



DAY – Destriped BT in VIIRS band M16 (12μm)

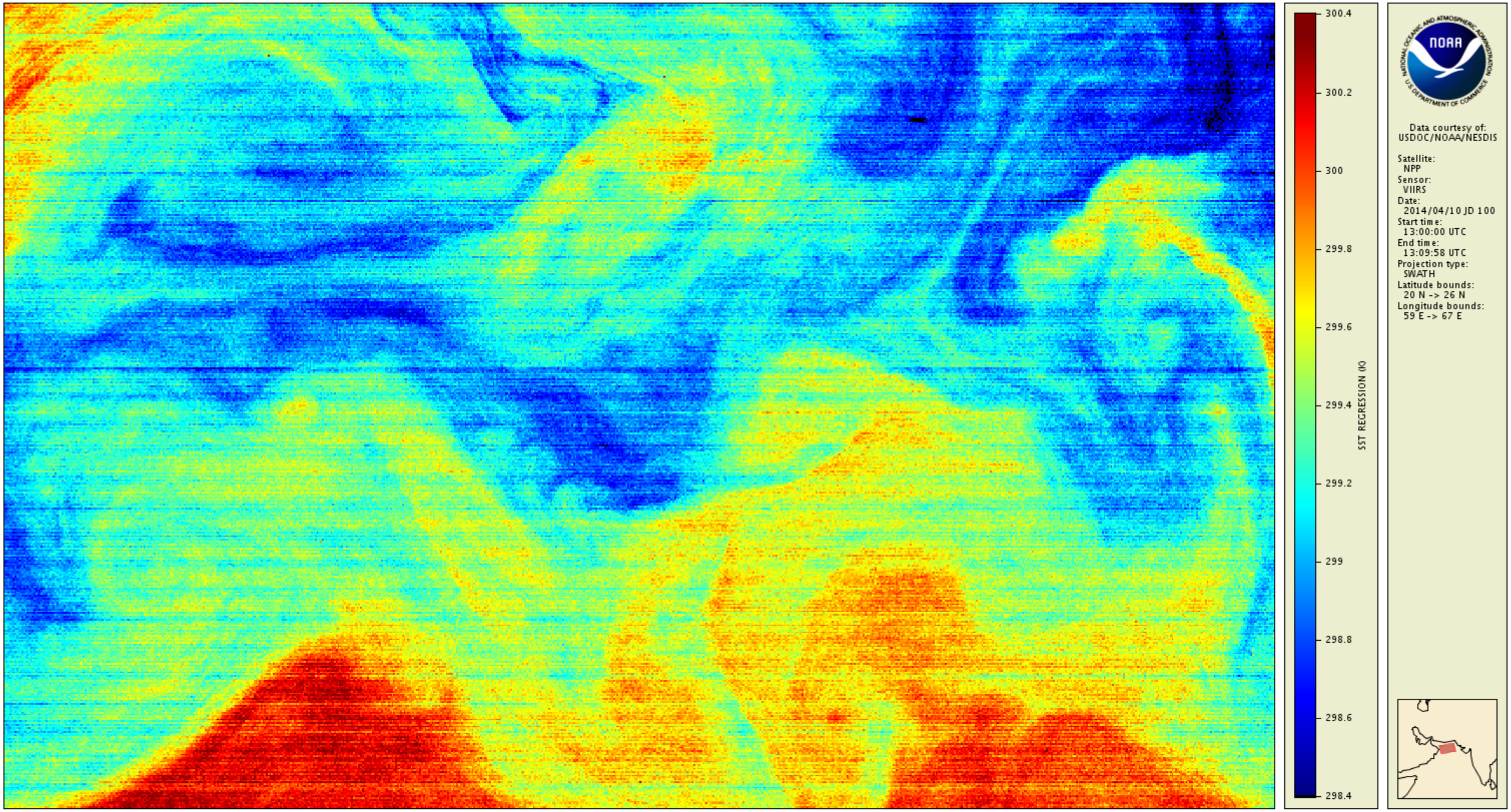


Daytime

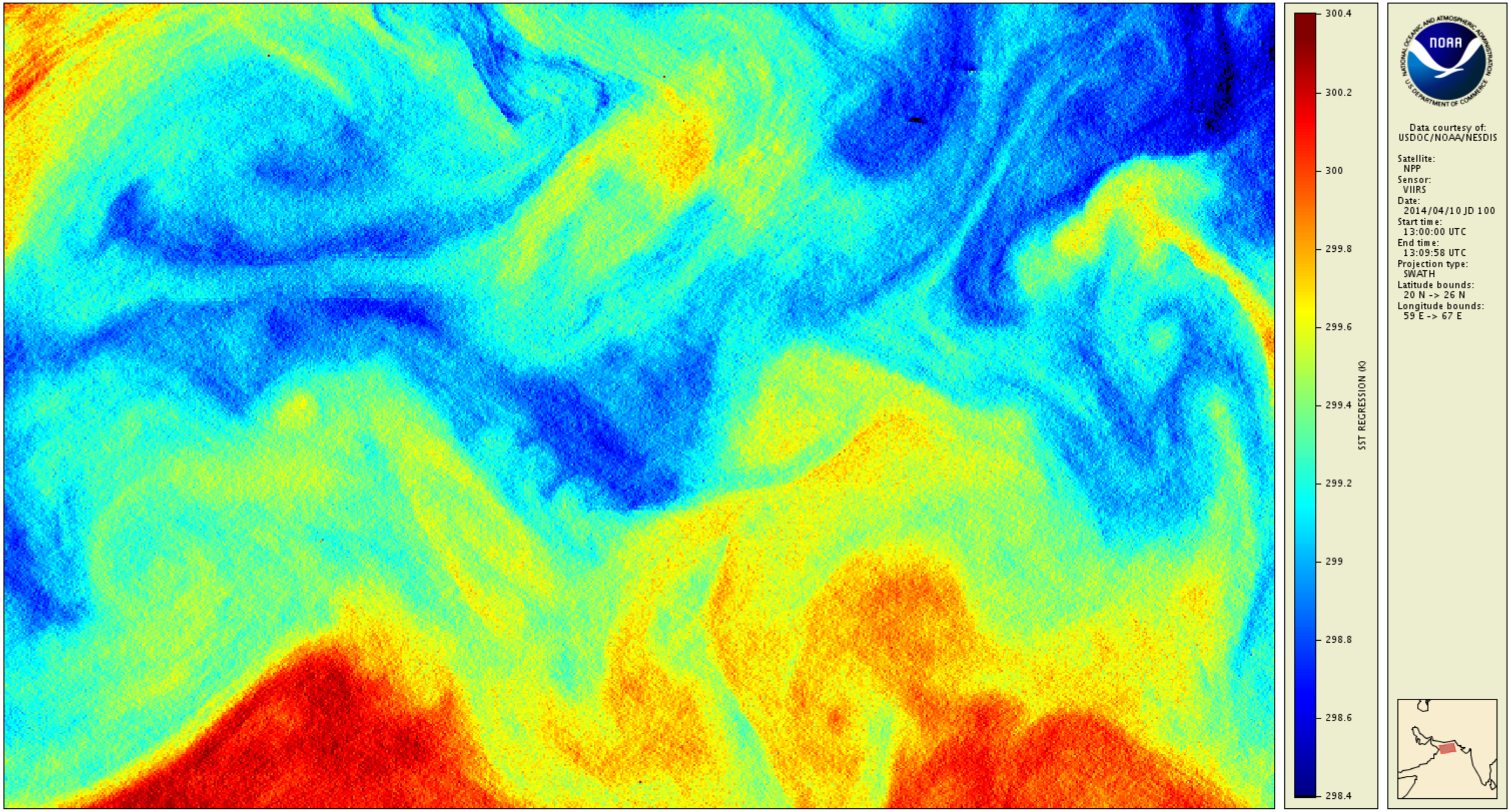
$$T_S = a_0 + (a_1 + a_2 S_\theta) T_{11} + [a_3 + a_4 T_S^0 + a_5 S_\theta] (T_{11} - T_{12}) + a_6 S_\theta$$

T_{11}, T_{12}	observed BTs in M15, M16
$S_\theta = 1/\cos(\theta)$	θ is view zenith angle
T_S^0	first guess SST (in ° C)
a's	regression coefficients

DAY – SST from original BTs in M15 and M16

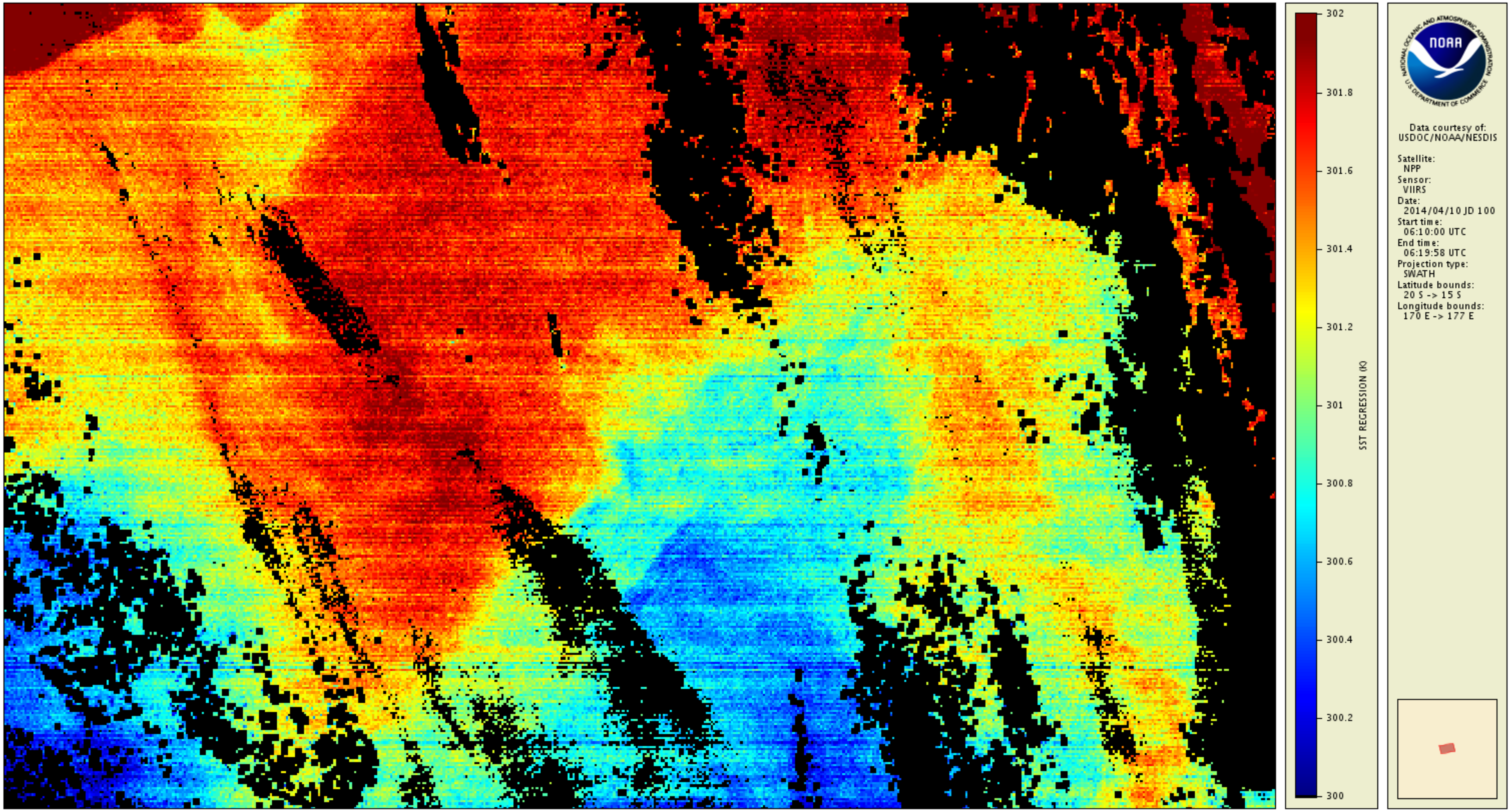


DAY – SST from destriped BTs in M15 and M16

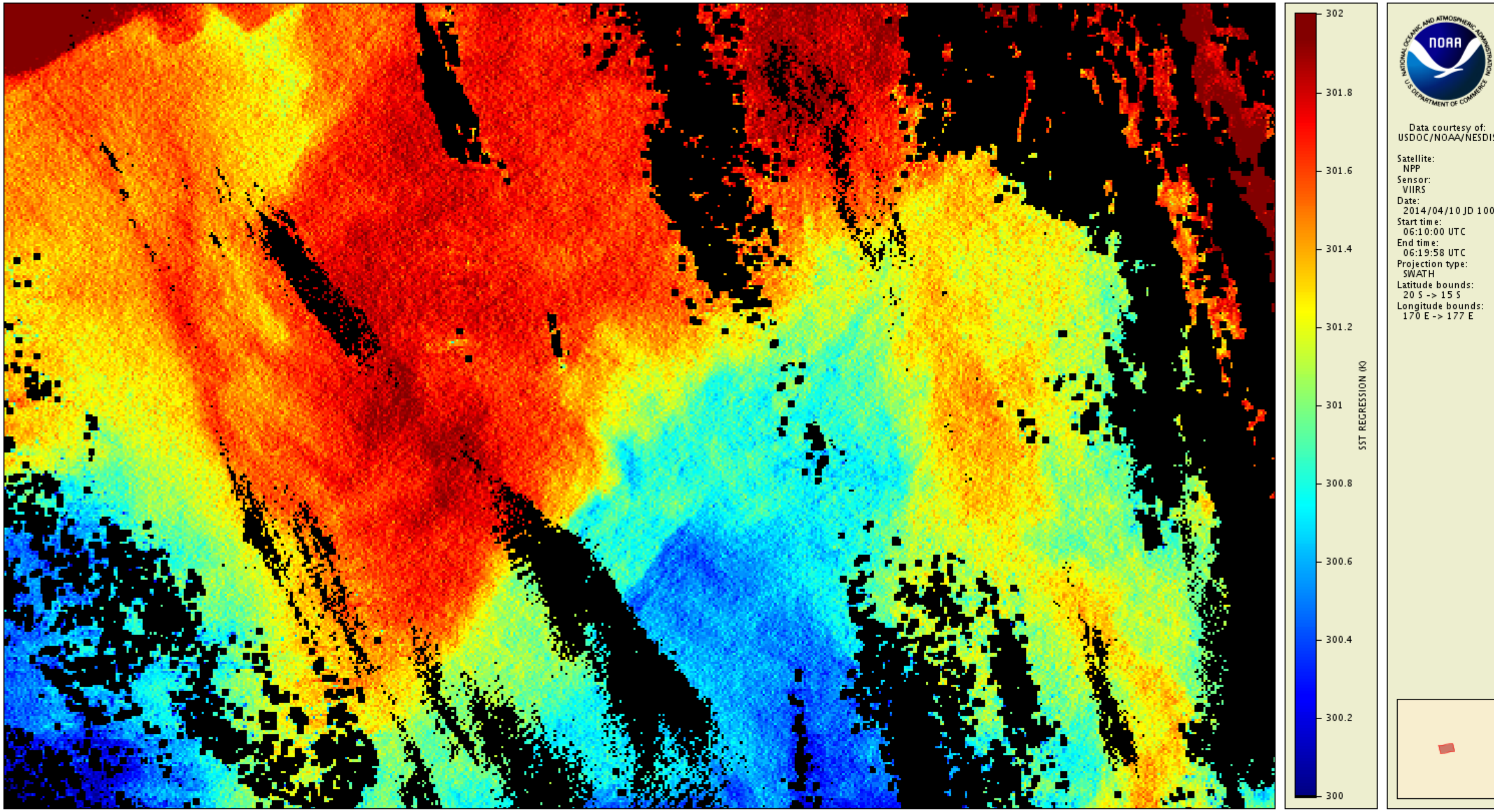


Effect of striping on ACSPO Clear-Sky Mask

DAY – SST from original BTs – effect on cloud mask



DAY – SST from destriped BTs – effect on cloud mask



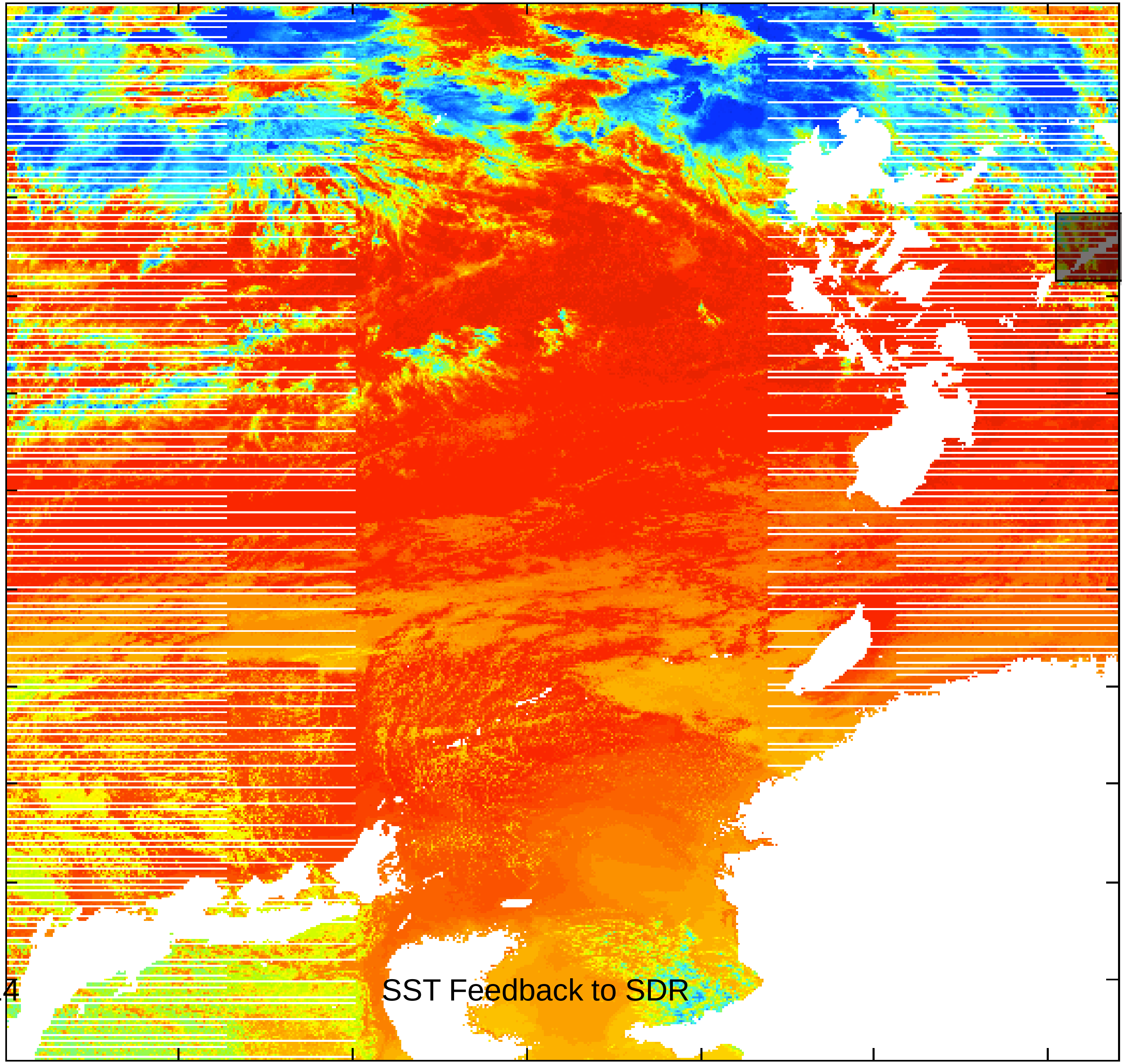
Performance – IDL vs C

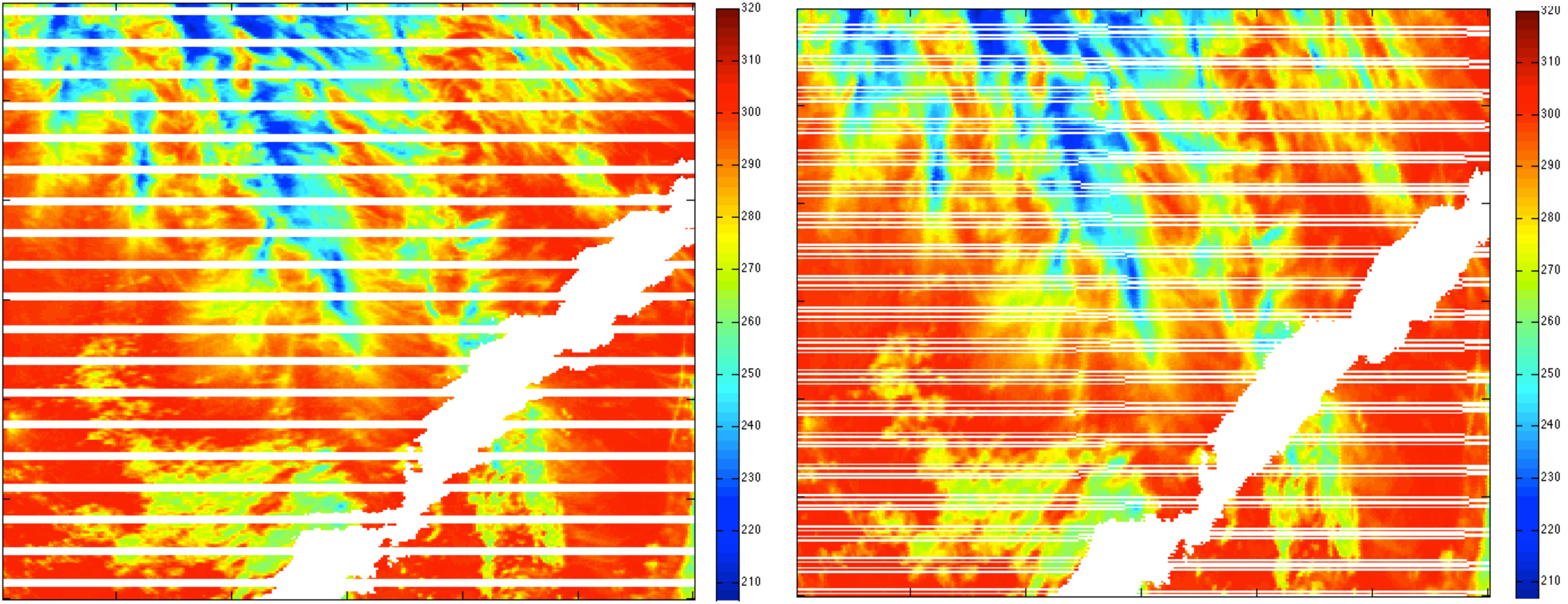
	IDL	C
Test environment	Intel Xeon 3.5 GHz NVIDIA Tesla M2070 GPU gpulib, cuda libraries	Intel Xeon 3.5 GHz 8 threads fftw3, openmp libraries
Running times		
One day of VIIRS (M12, M15, M16)	6 hours	37 min
One day of MODIS (Aqua + Terra) Bands 20, 31, 32	6 hours	83 min
One day of VIIRS (M12, M15, M16) + MODIS (Aqua + Terra) Bands 20, 31, 32	**12 hours**	**2 hours**

- overall, C code is about 6 times faster
- I/O is a significant factor for C version: ≈25% time (VIIRS) and ≈40% time (MODIS)

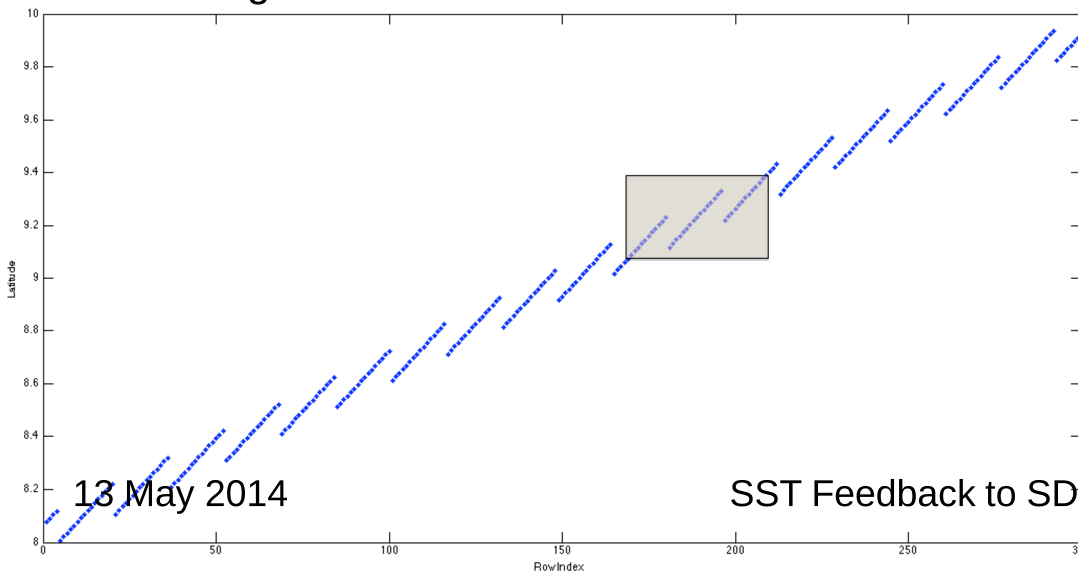
Swath imagery affected by bow-tie & small navigation misalignments

ACSPO_V2.20_NPP_VIIRS_2013-02-16_0430-0440_20130219.232756.nc

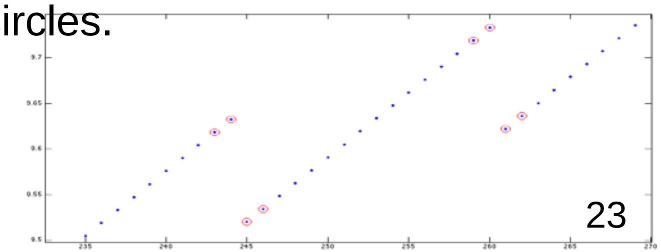




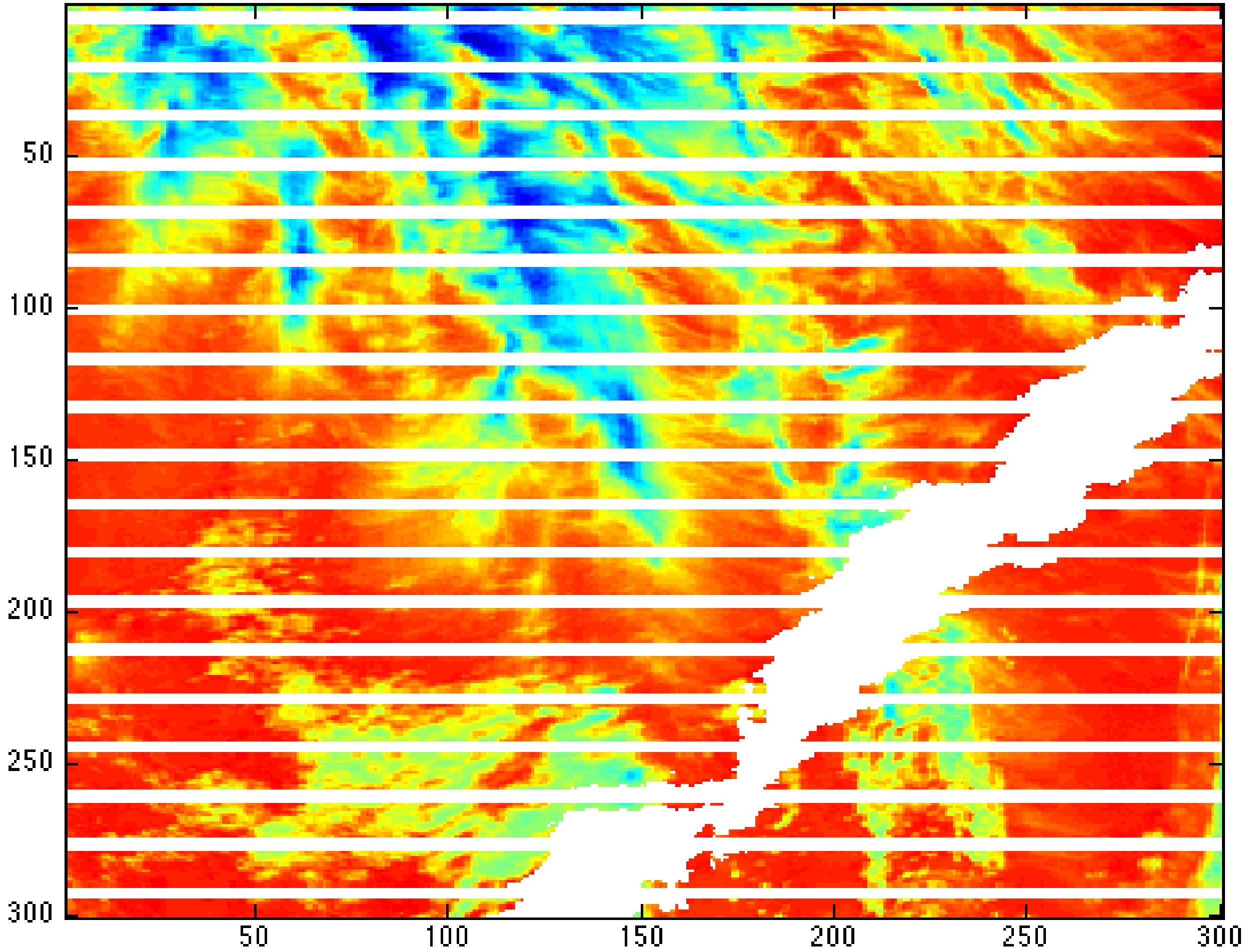
Left: Original SST Regression from ACSPO product. Right: Resampled Version corresponding to non-decreasing latitude values. The total number of “masked out rows” is the same as in original.



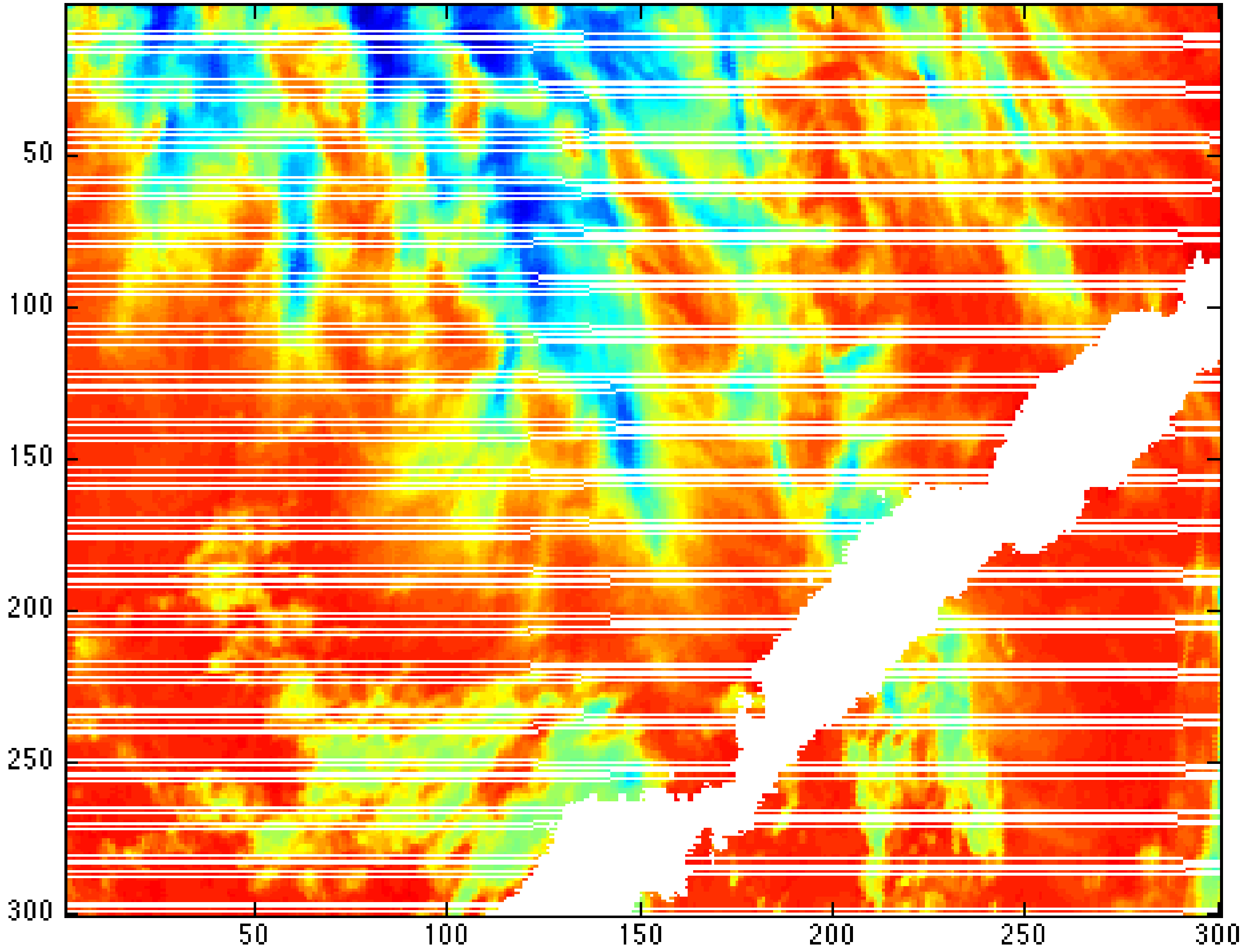
Overlapping pattern of latitude values for a fixed column. NaNs in SST correspond to locations marked by red circles.



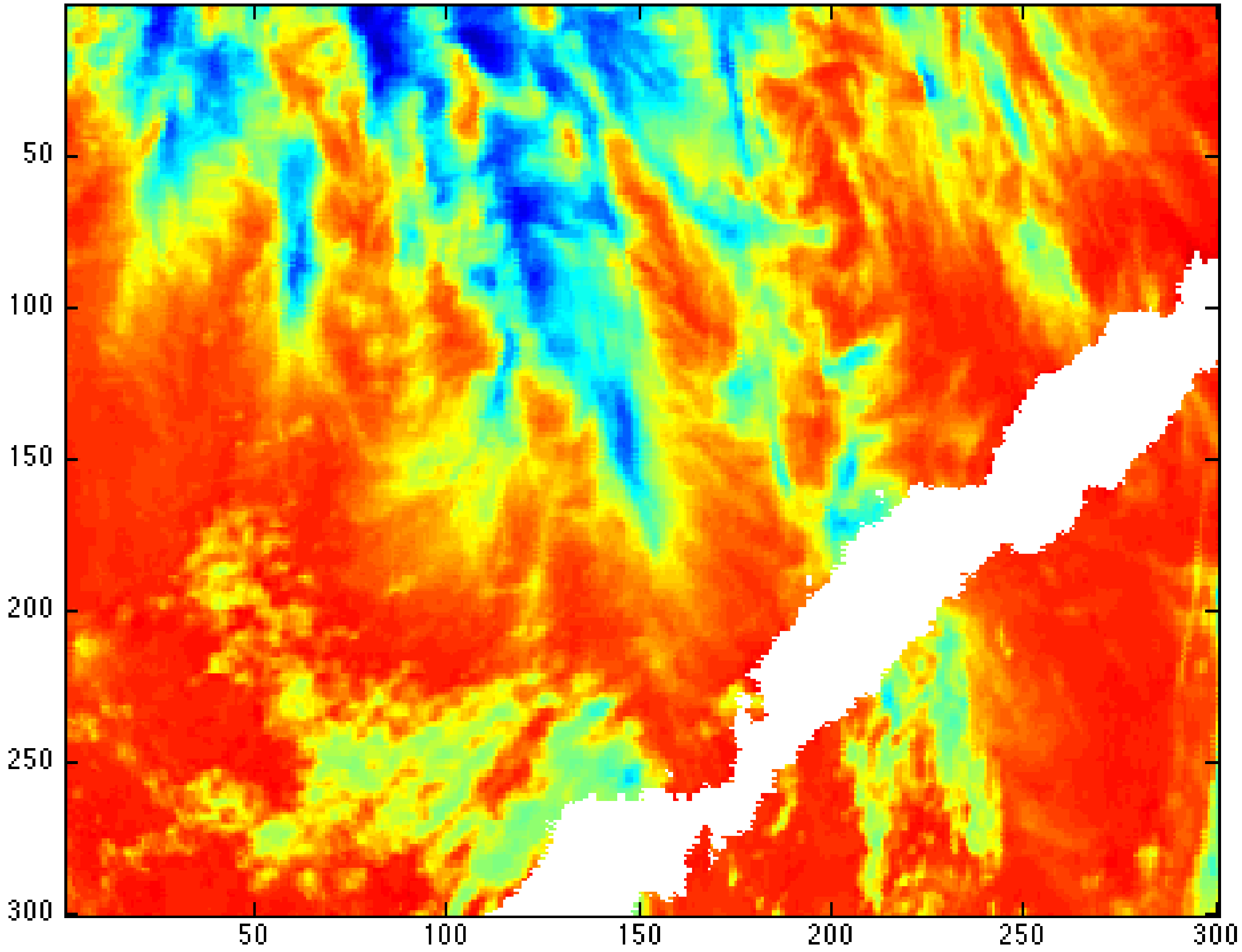
Original SST Regression Values at the bow tie region

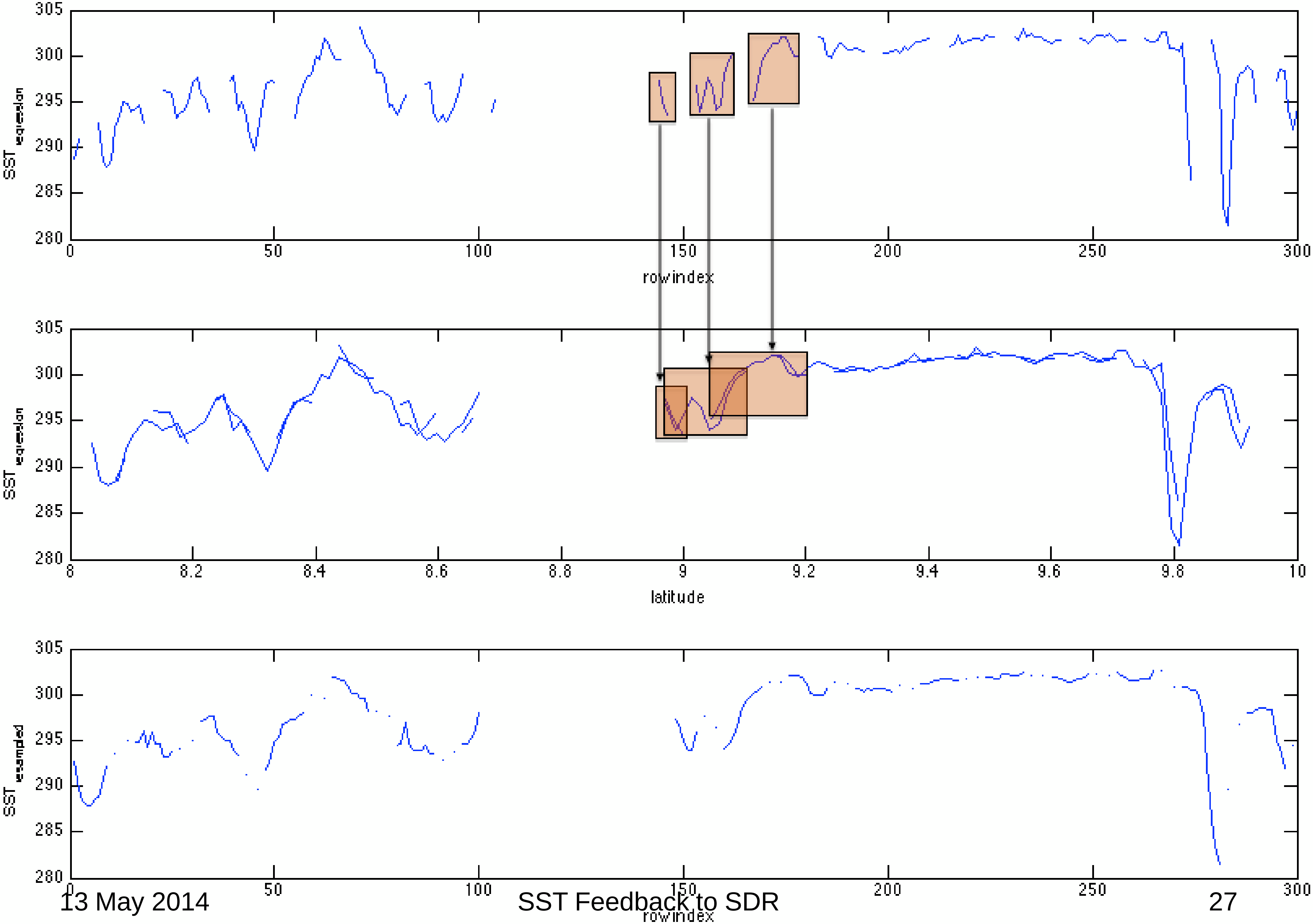


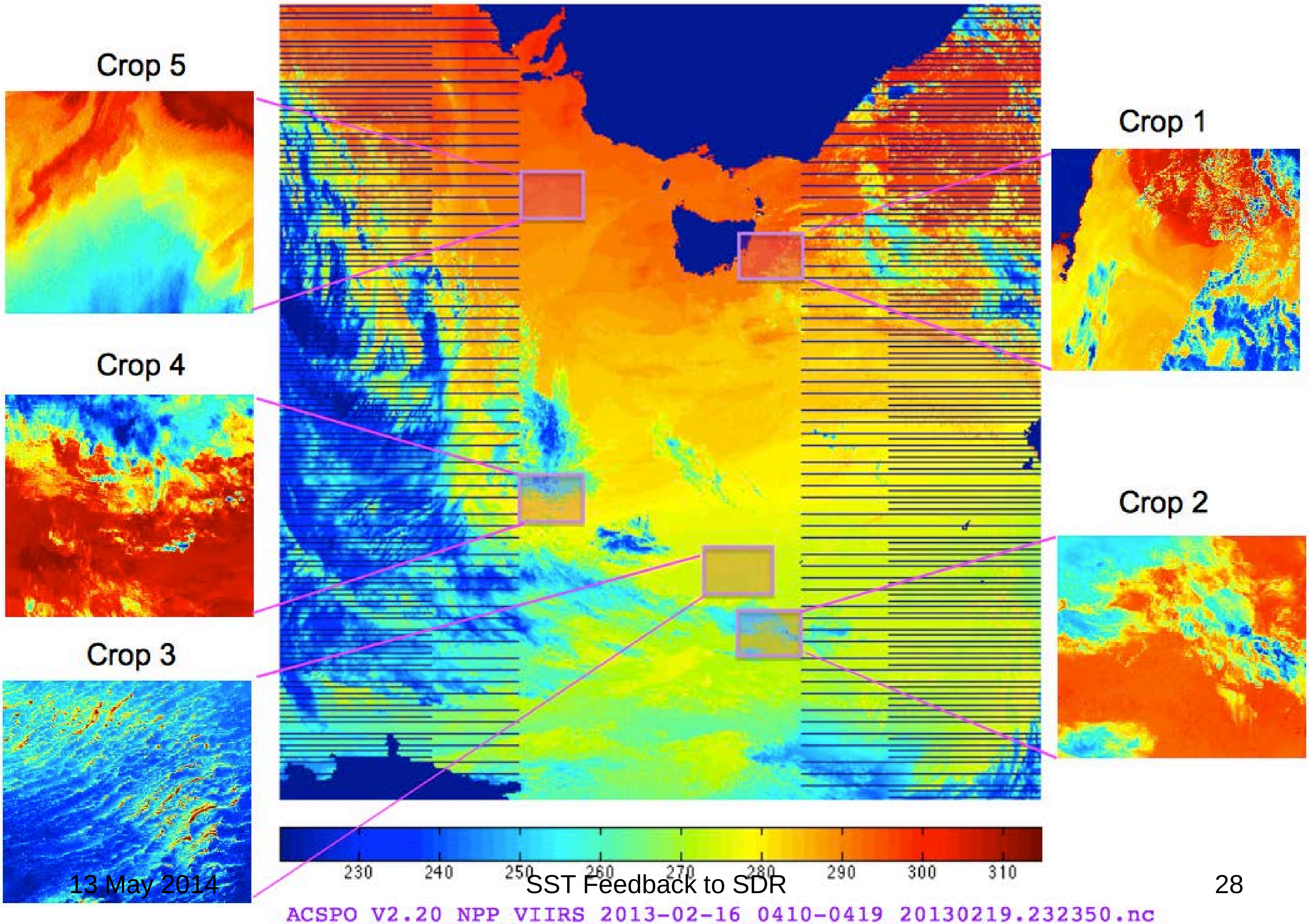
Resampled SST Values with monotonic Latitude values. No Interpolation



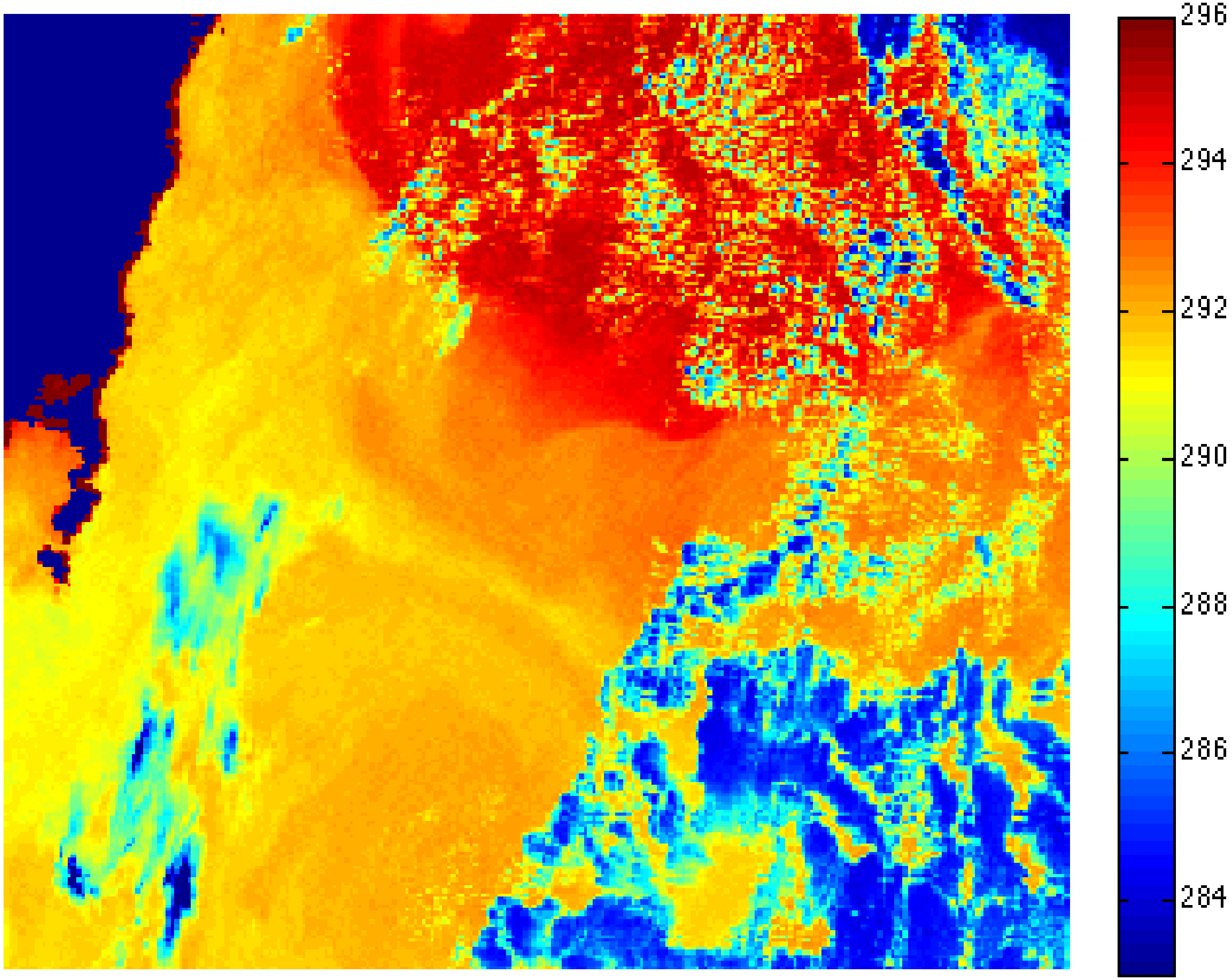
Resampled using 1D median filter over bow tie areas.



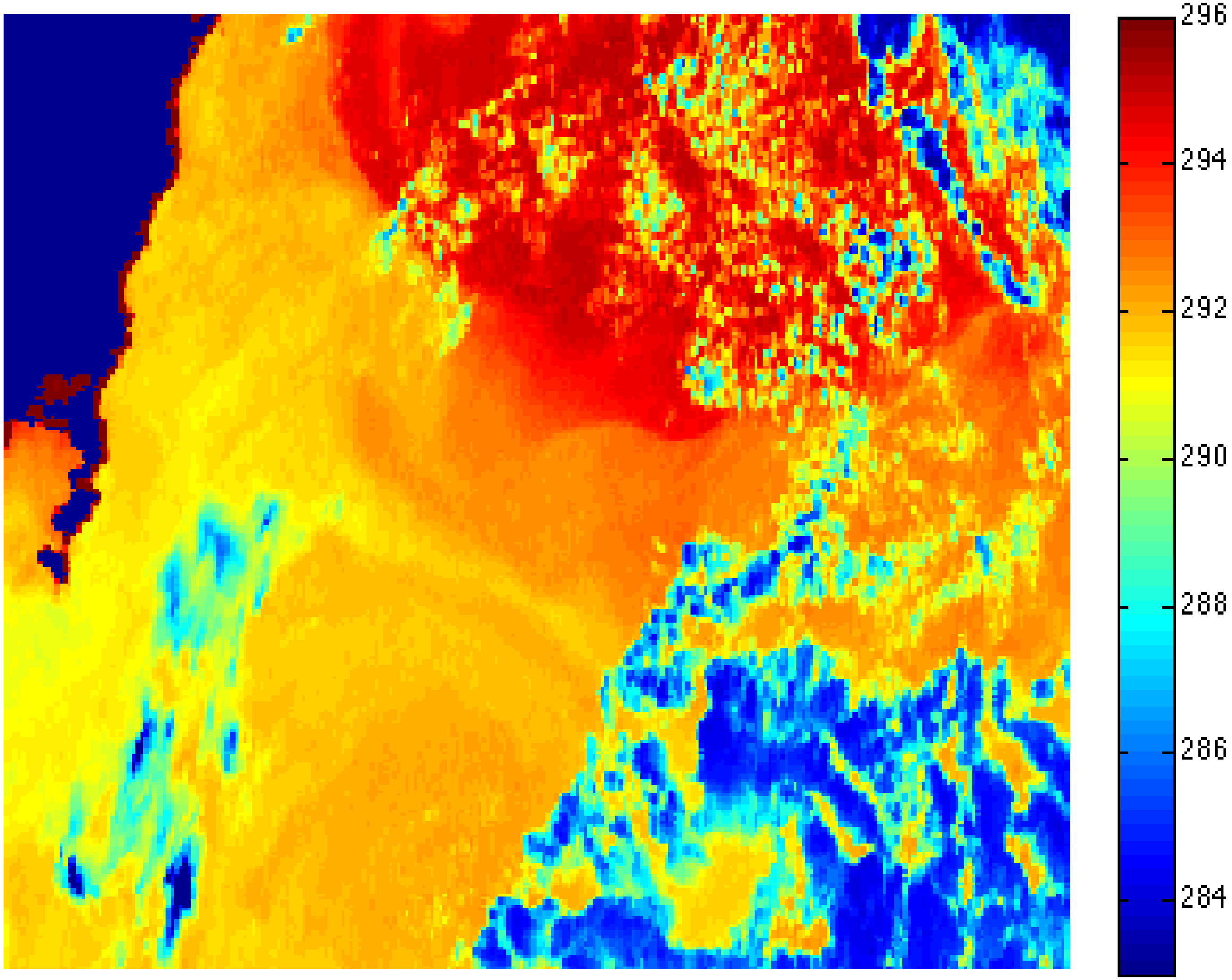

305
300
295
290
285
280
$SST_{regression}$
0
50
100
150
200
250
300
rowindex
latitude
8
8.2
8.4
8.6
8.8
9
9.2
9.4
9.6
9.8
10
$SST_{resampled}$


Crop 5
Crop 4
Crop 3
Crop 1
Crop 2
230
240
250
260
270
280
290
300
310
ACSPO_V2.20_NPP_VIIRS_2013-02-16_0410-0419_20130219.232350.nc

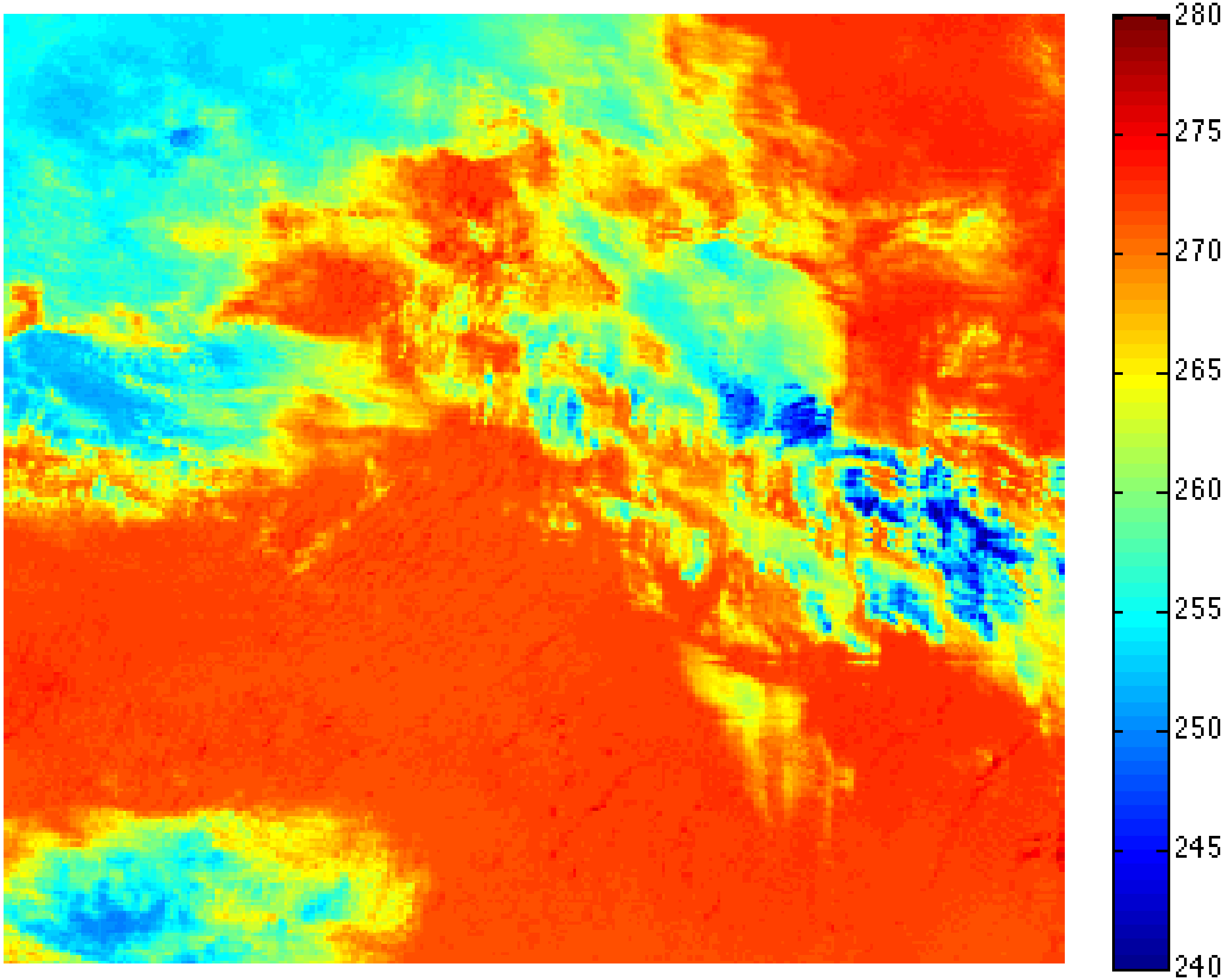
Retrieved SST: Crop 1



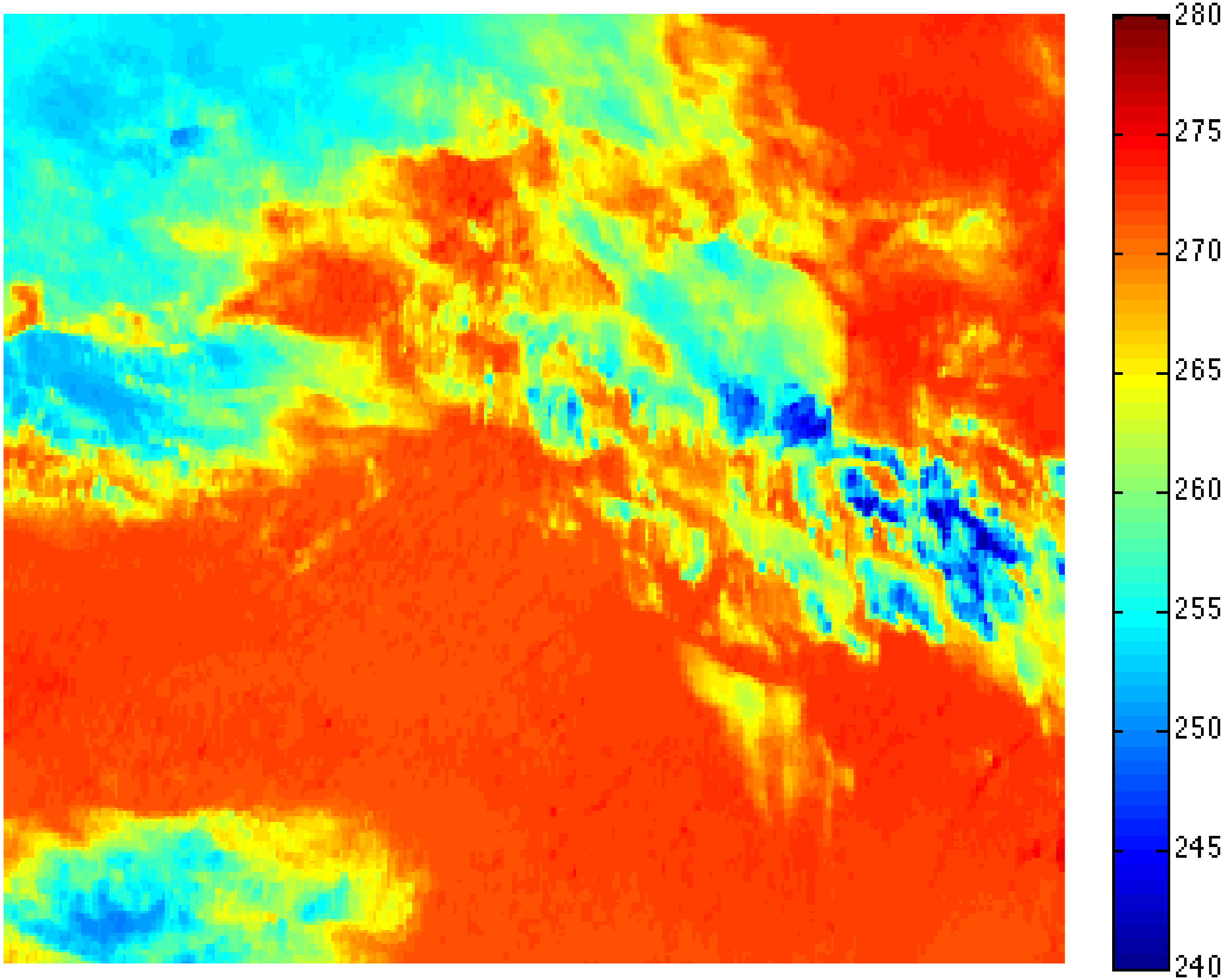
Resampled SST: Crop 1



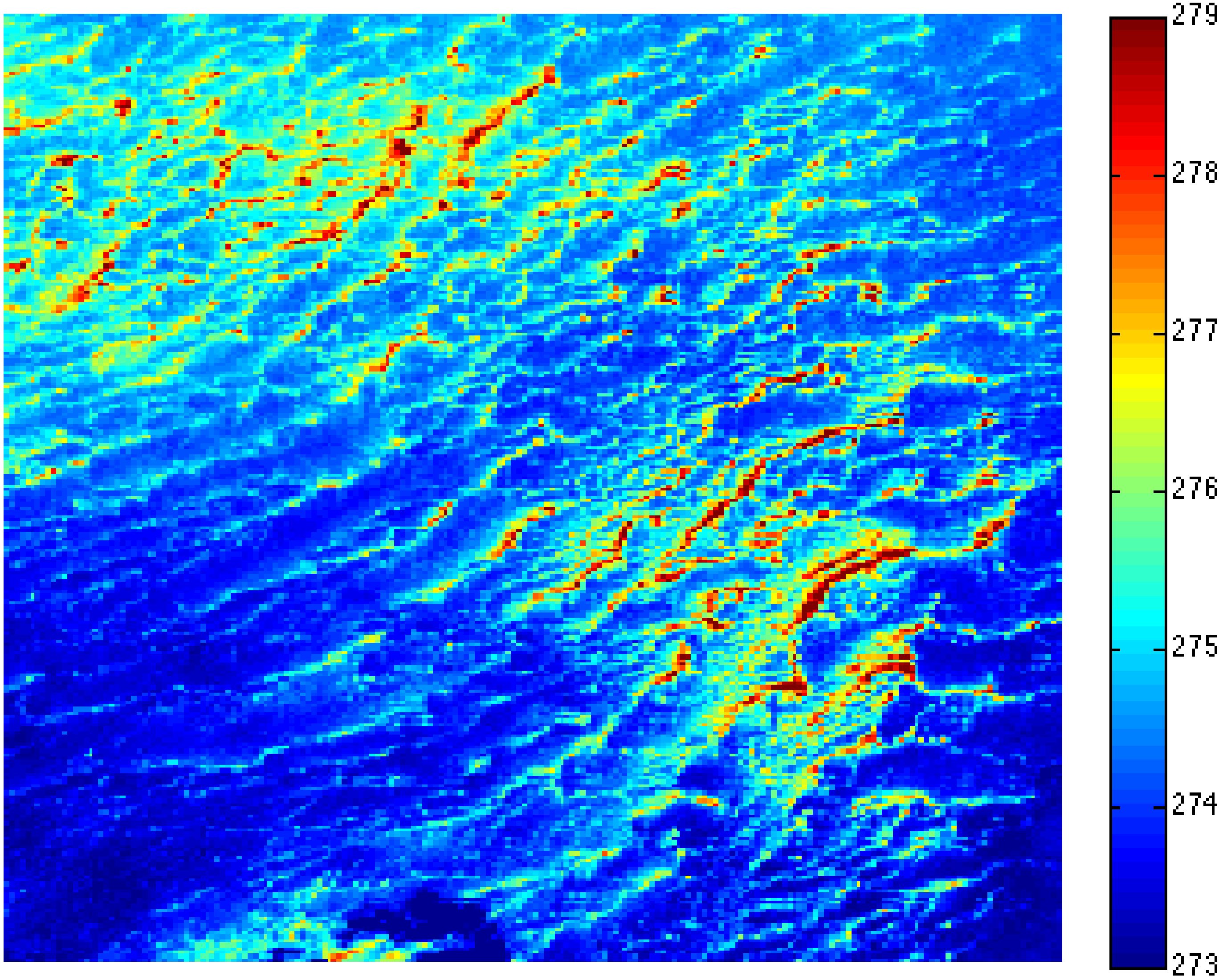
Retrieved SST: Crop 2



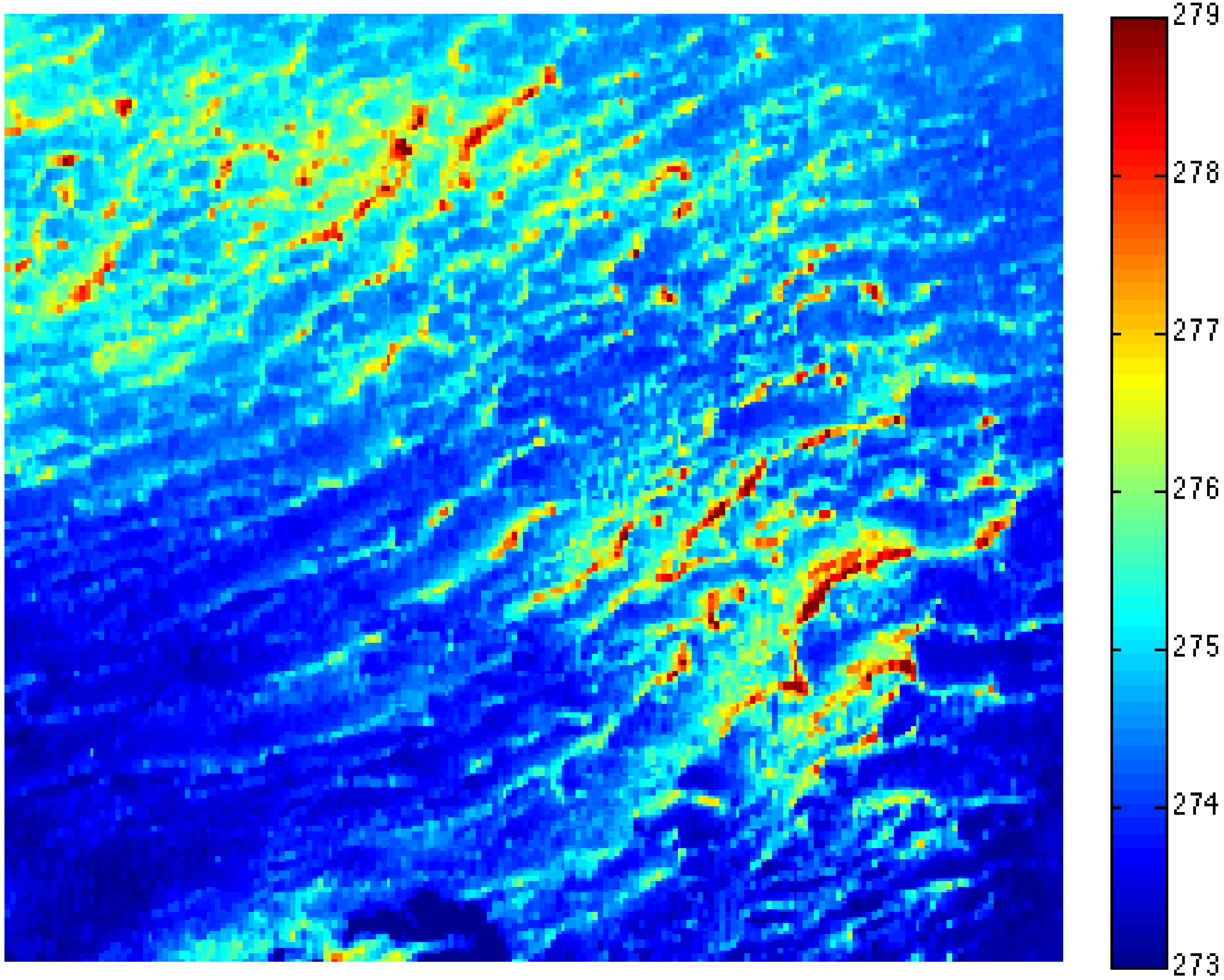
Resampled SST: Crop 2



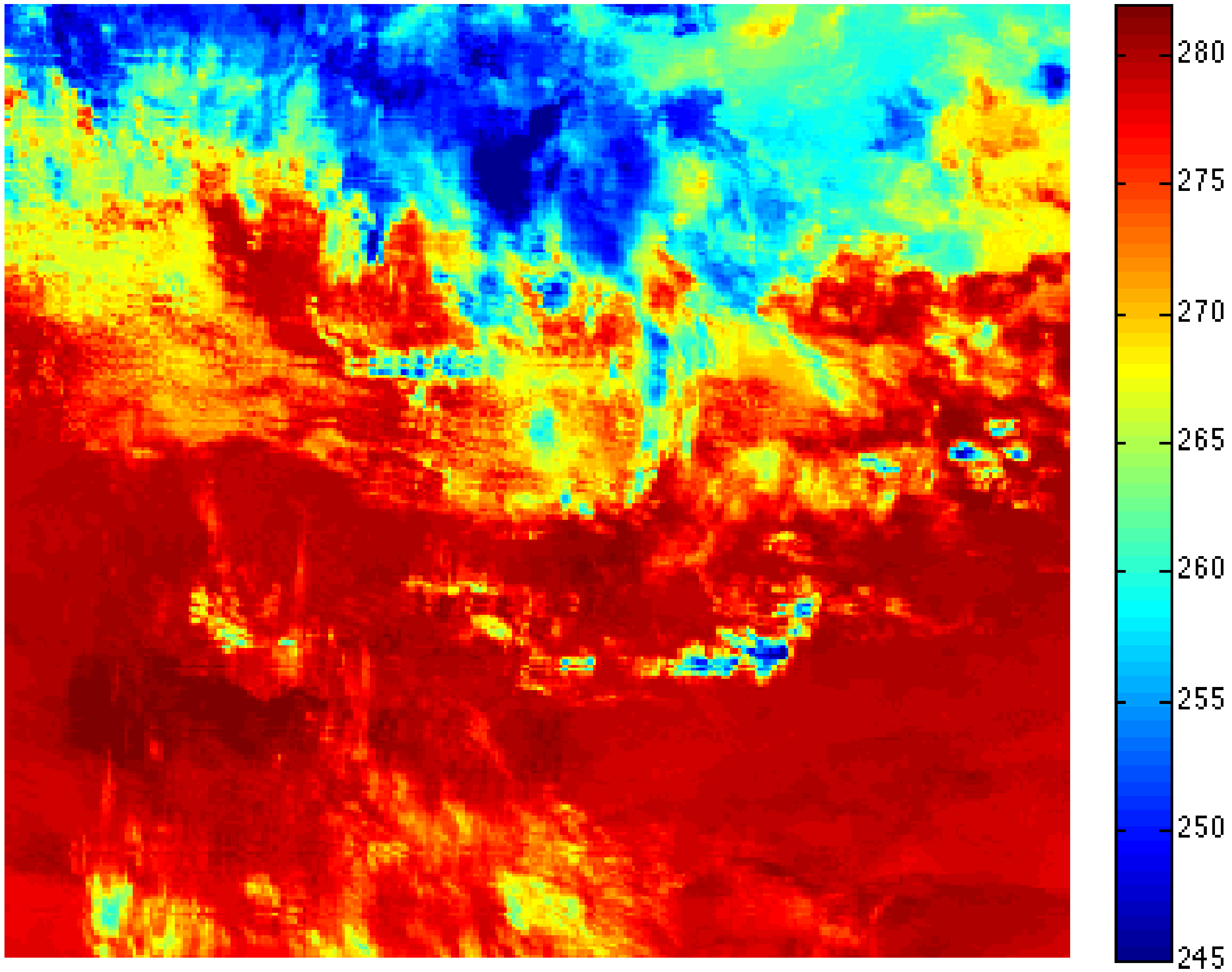
Retrieved SST: Crop 3



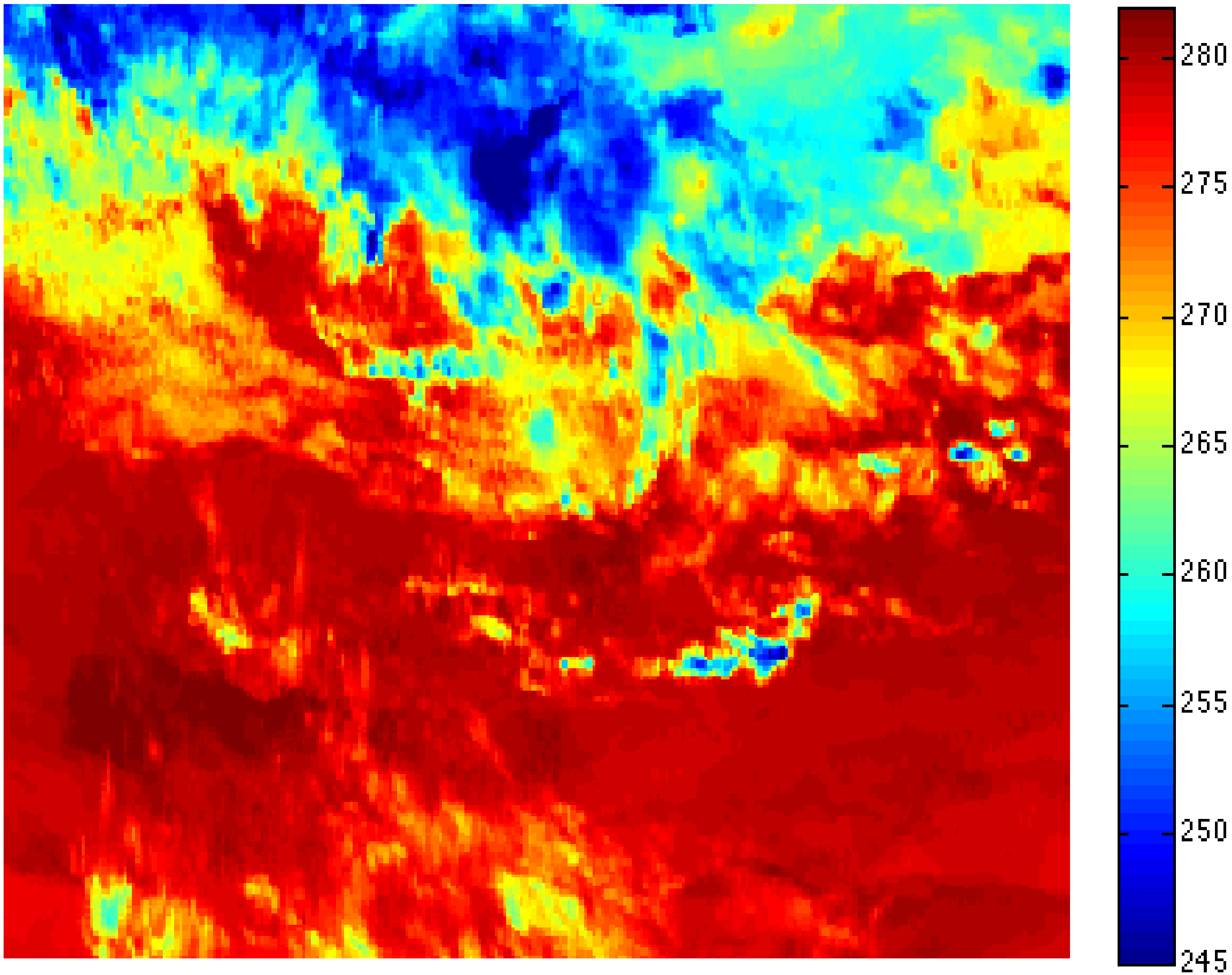
Resampled SST: Crop 3



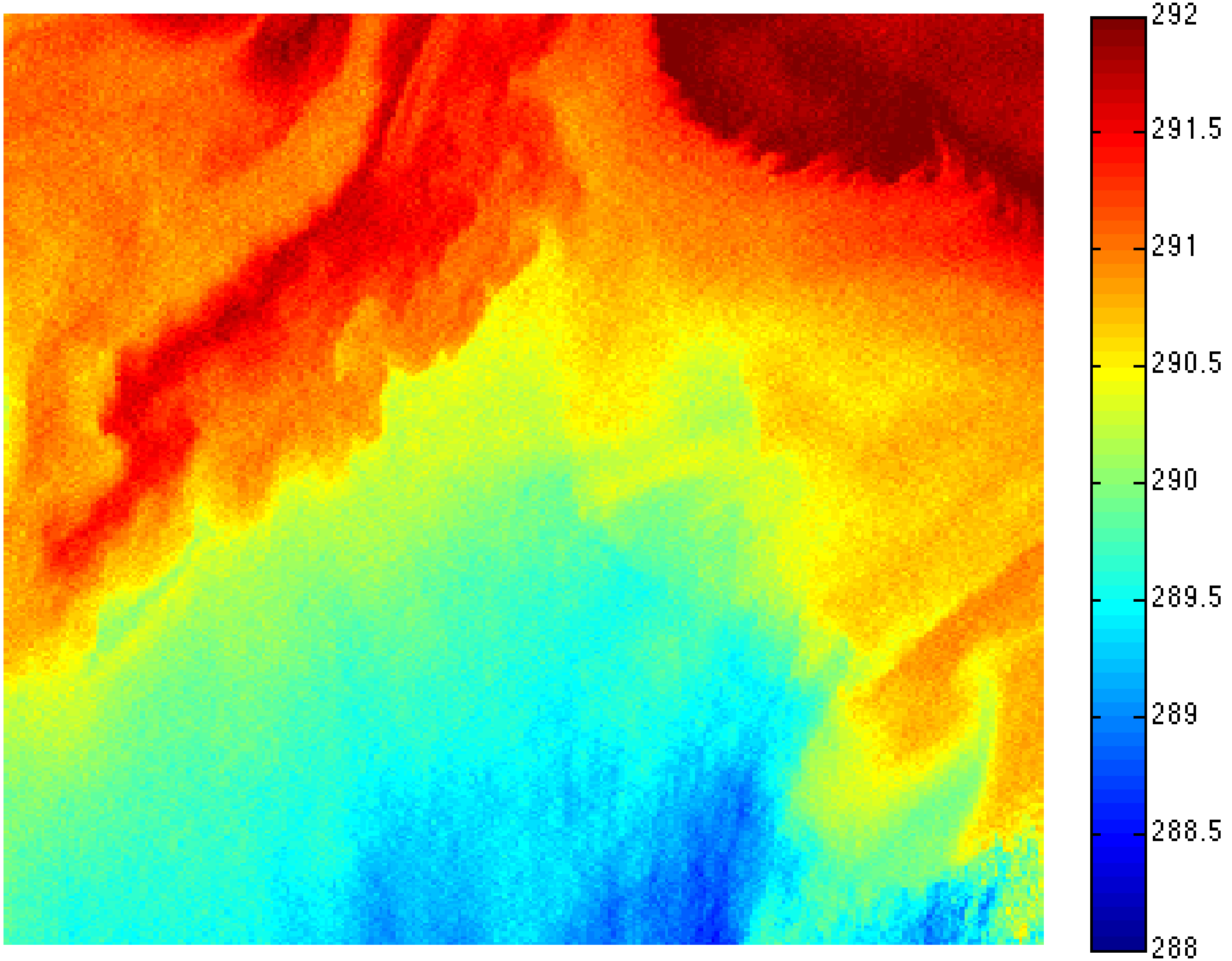
Retrieved SST: Crop 4



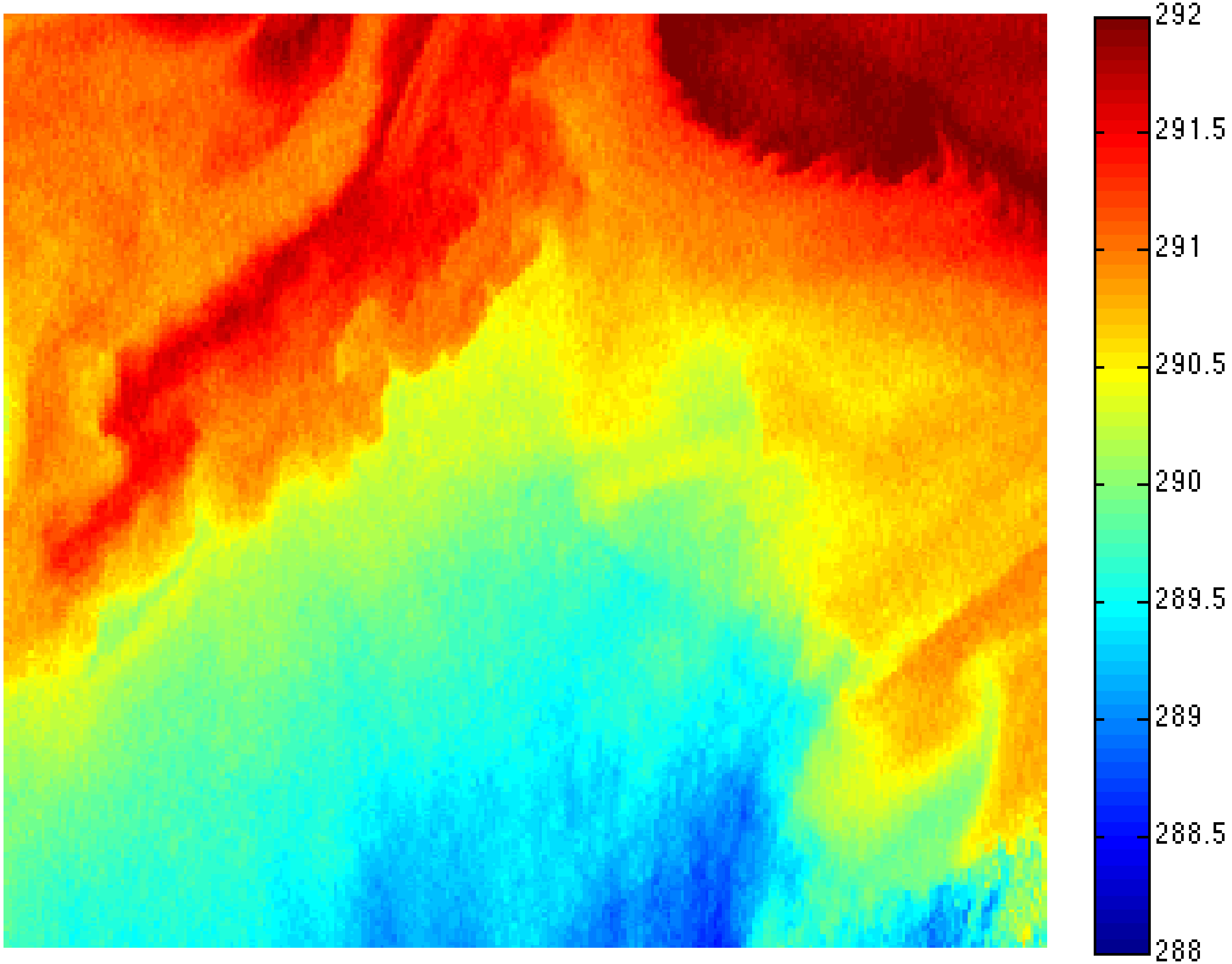
Resampled SST: Crop 4



Retrieved SST: Crop 5



Resampled SST: Crop 5



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