Scanner Characteristics

MODIS Orbit and Scan Geometry

Terra: 10:30 am local descending

Aqua: 1:30 pm local ascending

Orbit period: 99 minutes

Repeat cycle: 16 days (same as Landsat)

Scan mirror: Double sided, 20.3 revs/minute

Scan rate: 1.477 scans/sec

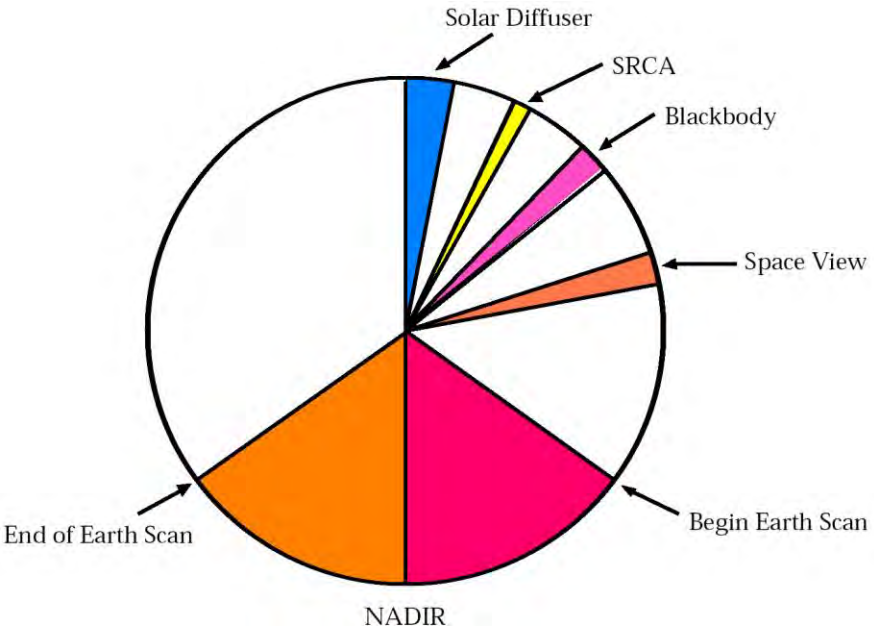
Scan angle: +/- 55 degrees

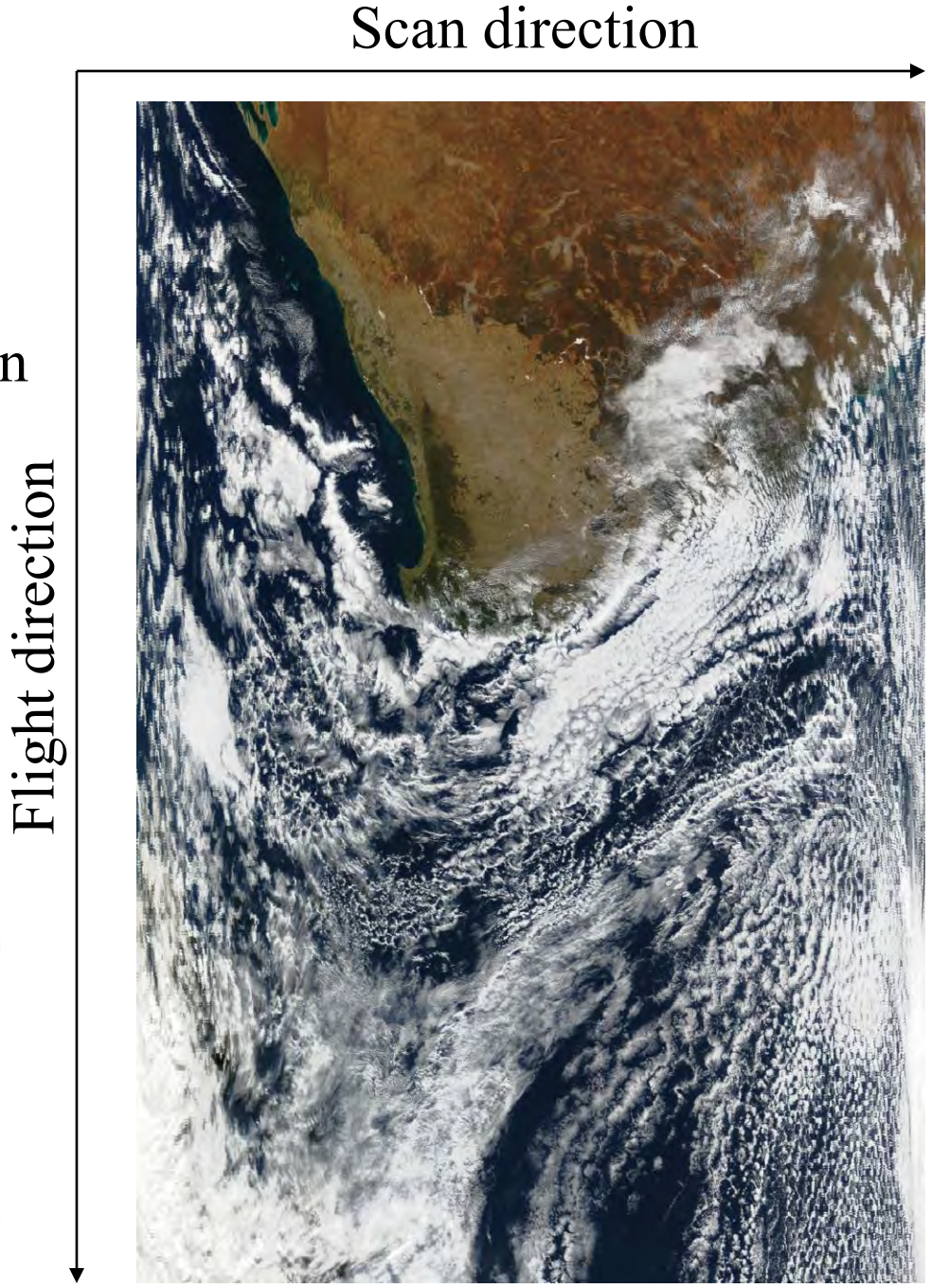
Swath width: 2330 km across track, 10 km along track

Image Acquisition Details

Scan sequence:

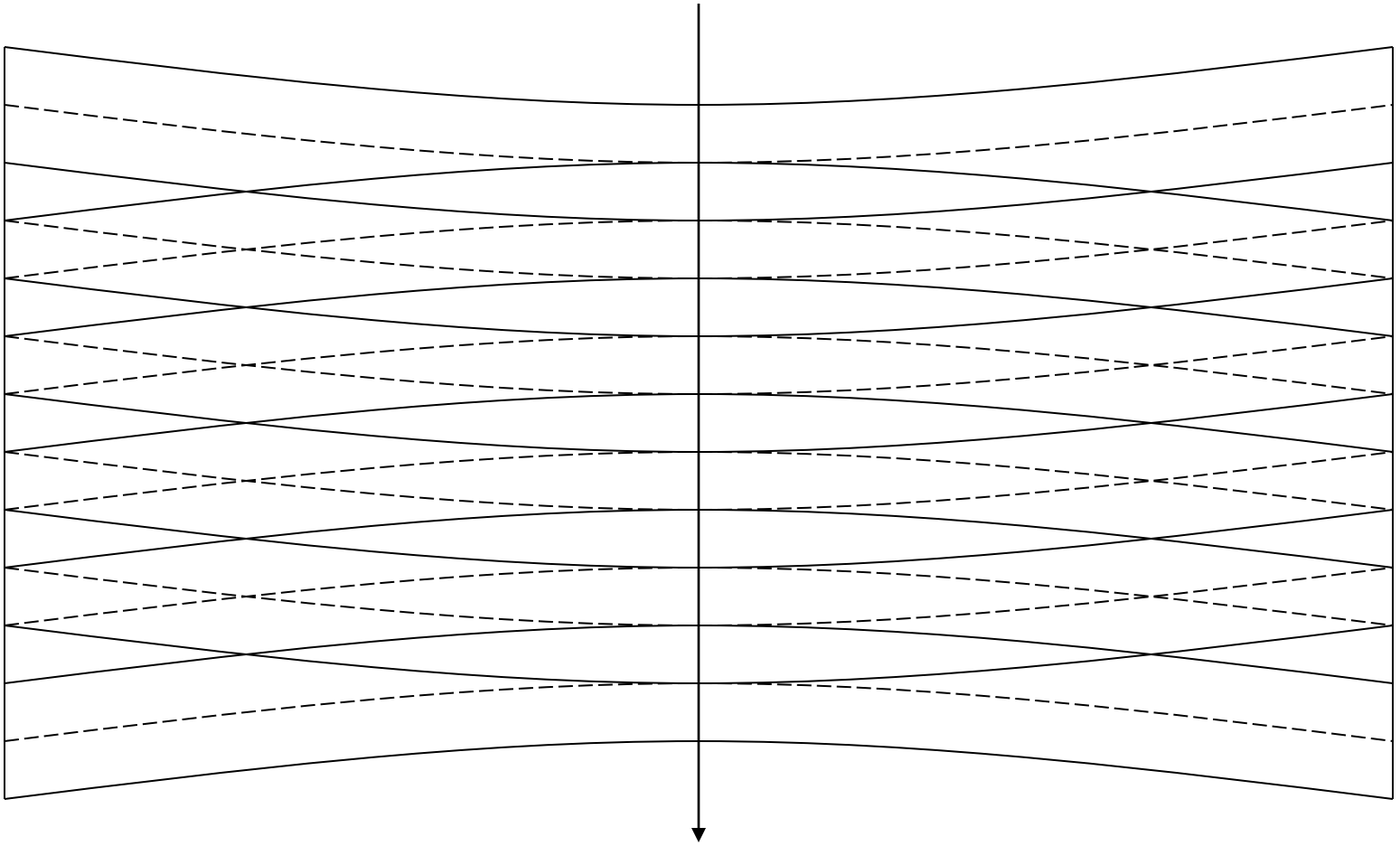
1. Solar diffuser
2. Spectroradiometric Calibration Assembly
3. Blackbody
4. Space View
5. Earth scan



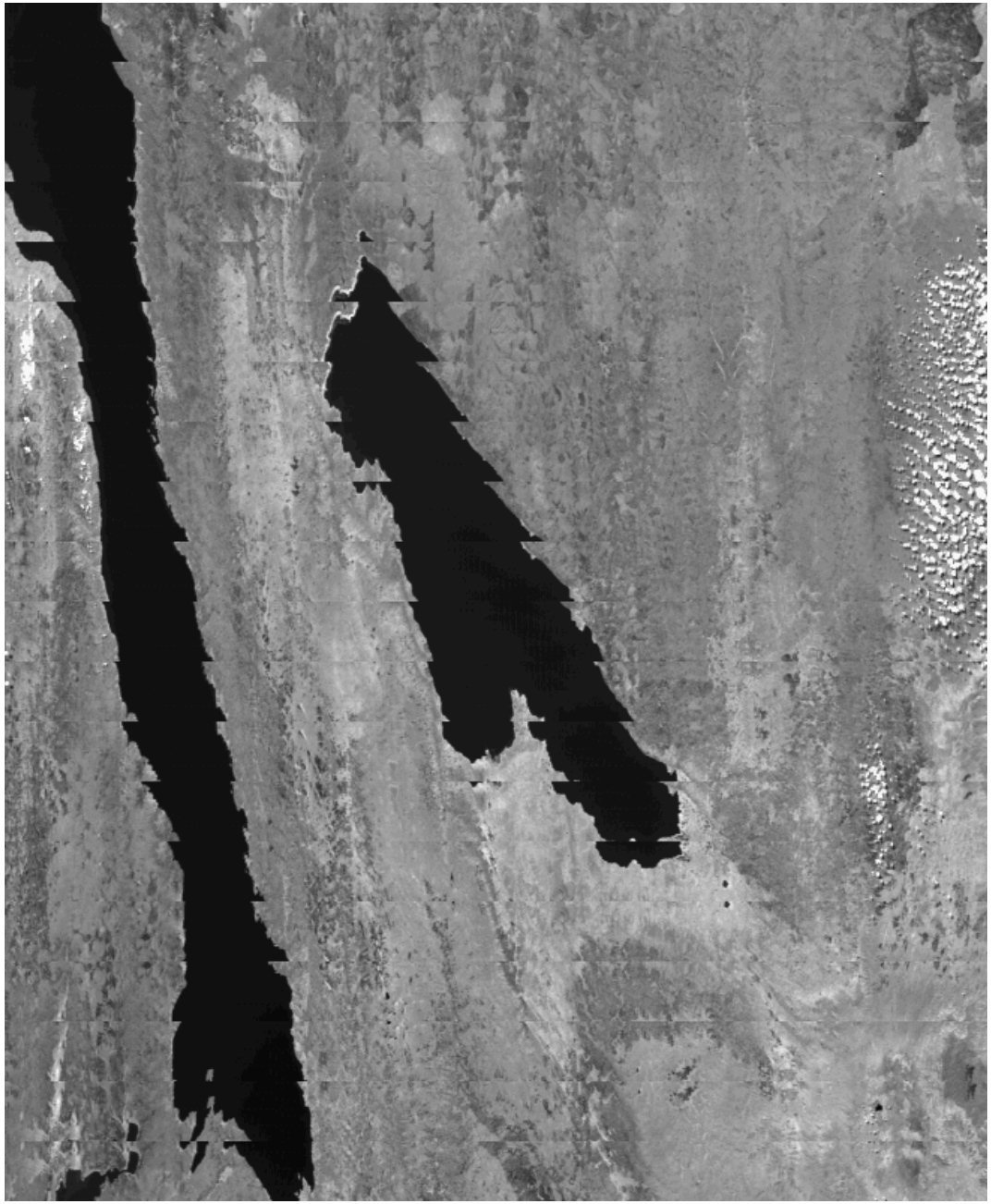


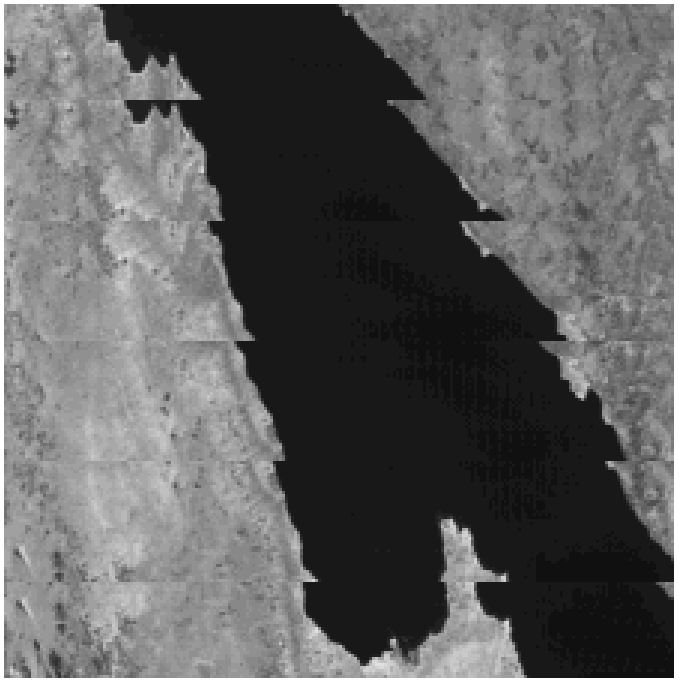
MODIS Bowtie Artifacts

Consecutive “bowtie” shaped scans are contiguous at nadir, and overlap as scan angle increases…



MODIS bowtie artifacts at edge of swath





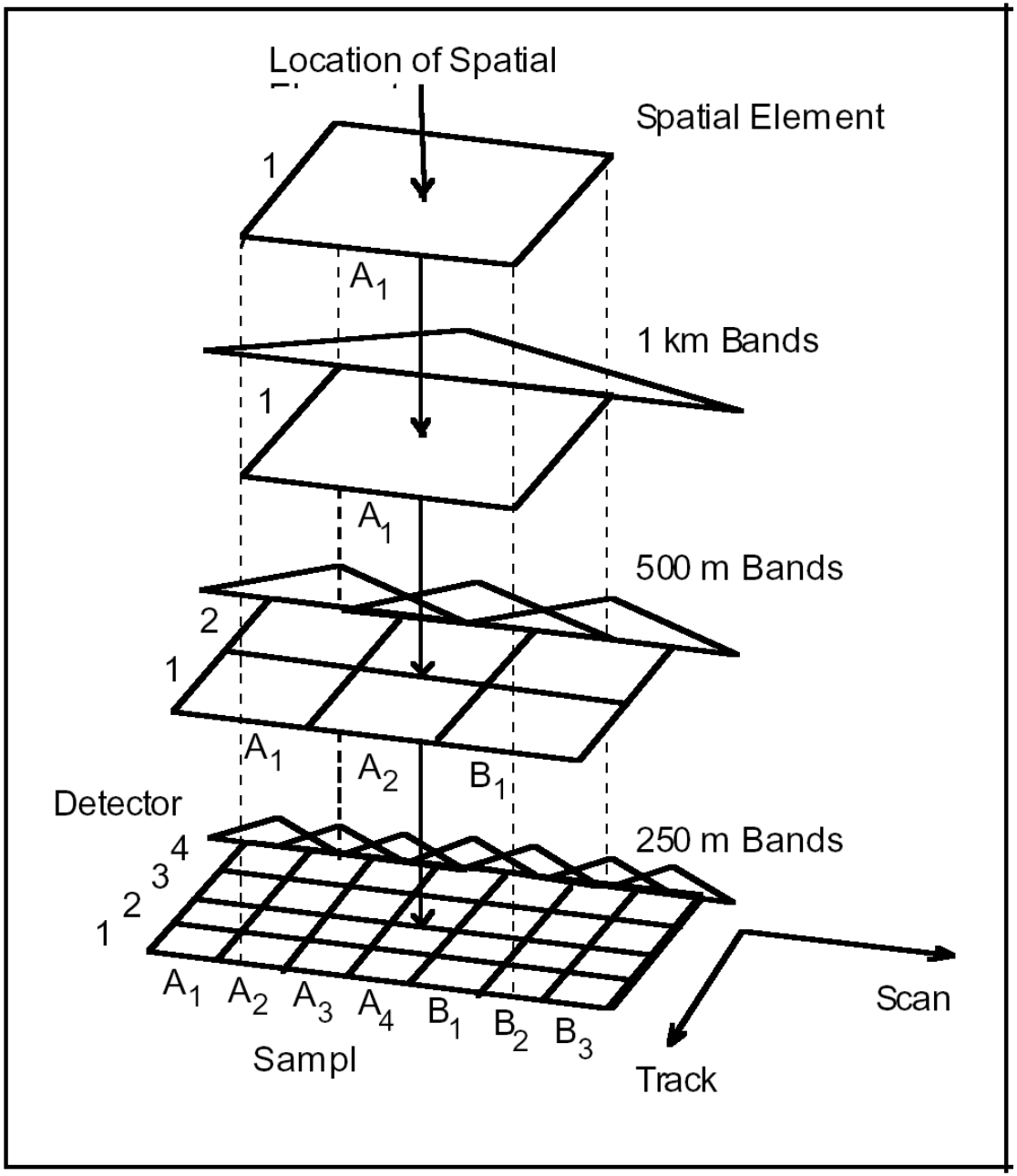
Band 2 (0.87 micron)

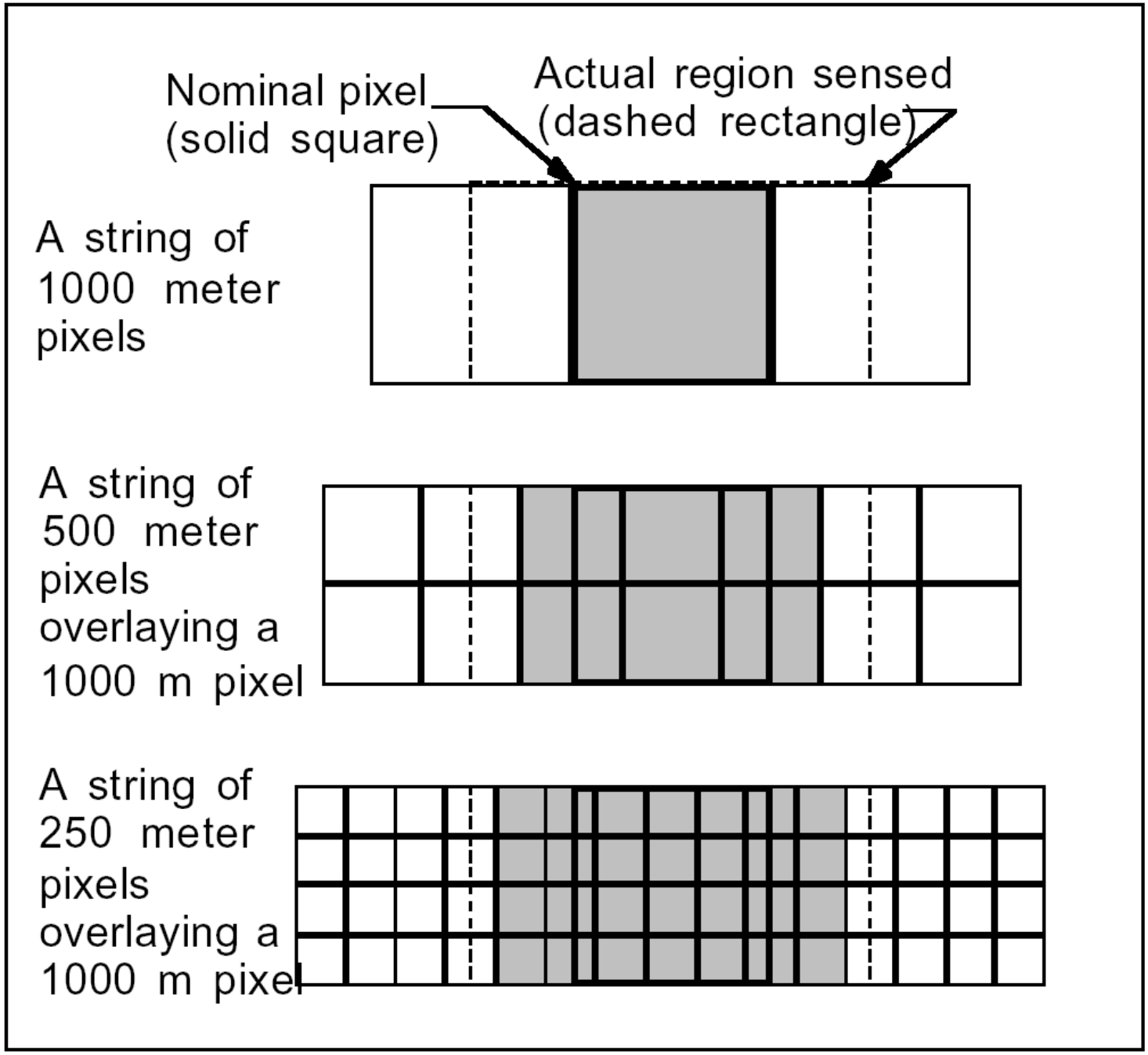
250 meter resolution

Bowtie Artifacts

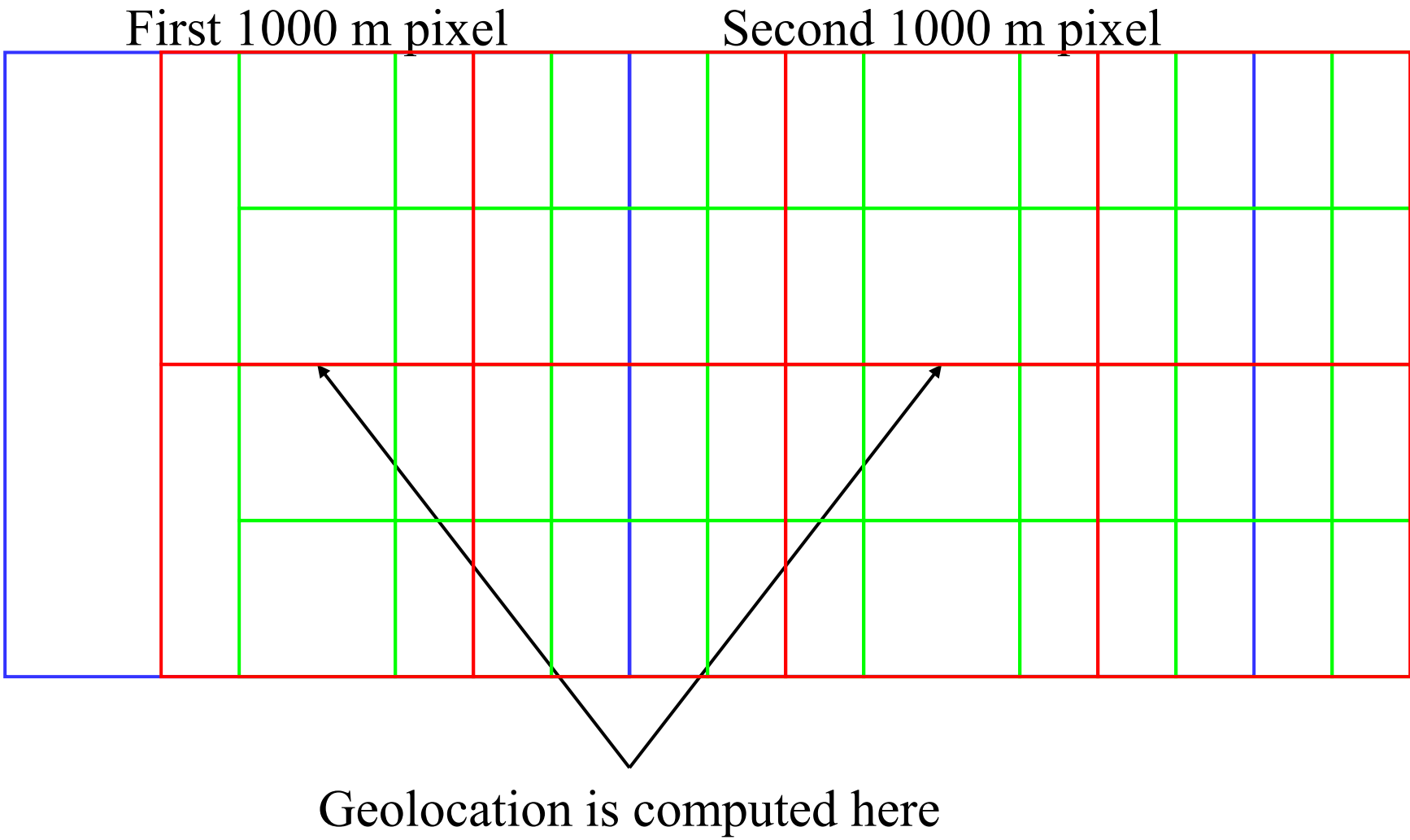
1. Are not a ‘problem’: they are a consequence of the sensor design
2. Can be removed for visualization purposes by reprojecting the image onto a map
3. Do not affect science algorithms that run on a pixel-by-pixel basis or within one earth scan
4. Will be present on next generation of operational polar orbiting imagers (VIIRS on NPP/NPOESS)

Inter-band Registration




Nominal pixel
(solid square)
Actual region sensed
(dashed rectangle)
A string of
1000 meter
pixels
A string of
500 meter
pixels
overlaying a
1000 m pixel
A string of
250 meter
pixels
overlaying a
1000 m pixel

Nominal MODIS inter-band registration

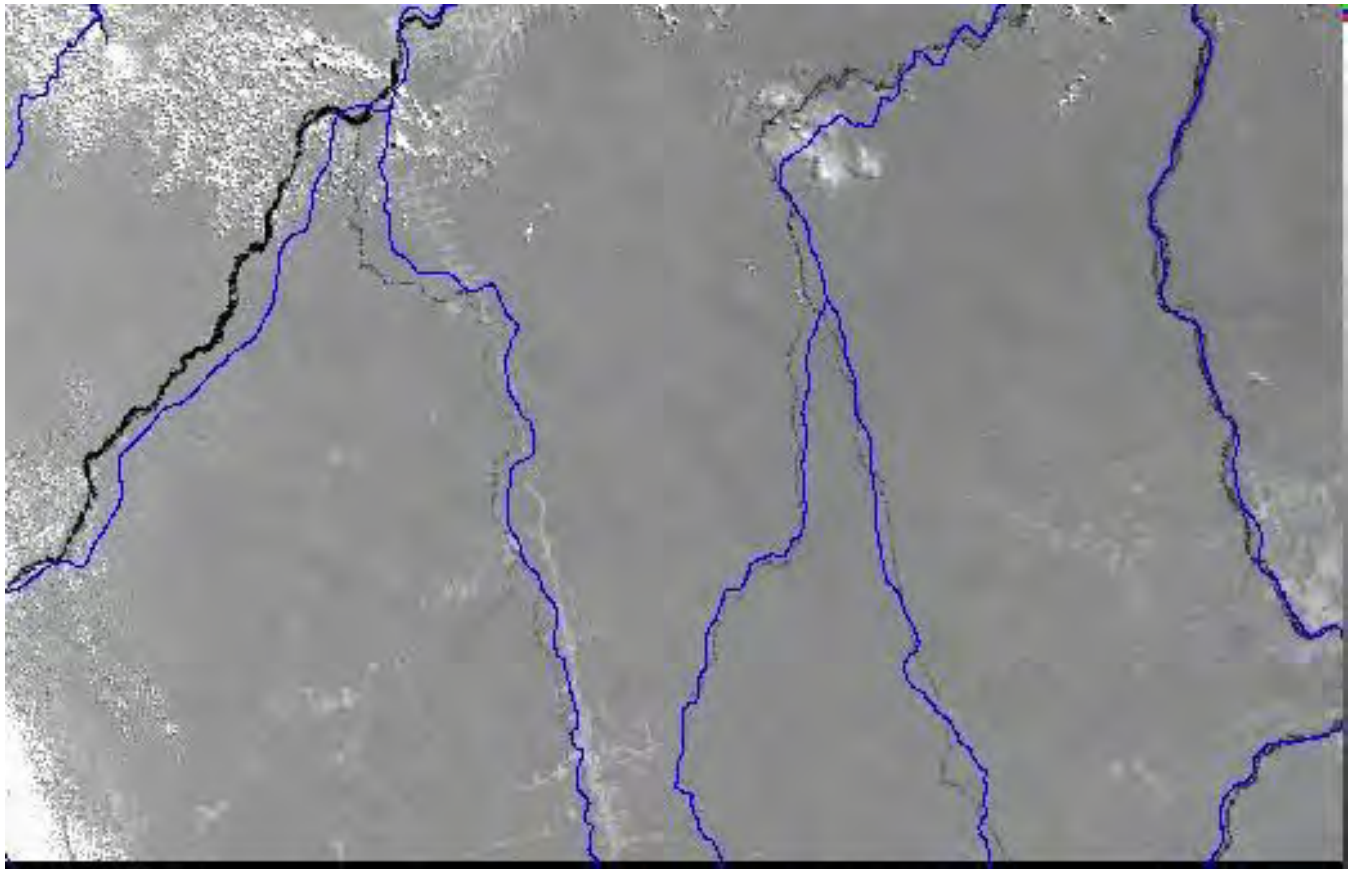


MODIS Geolocation

Earth locations computed for every 1000 meter pixel (WGS84):

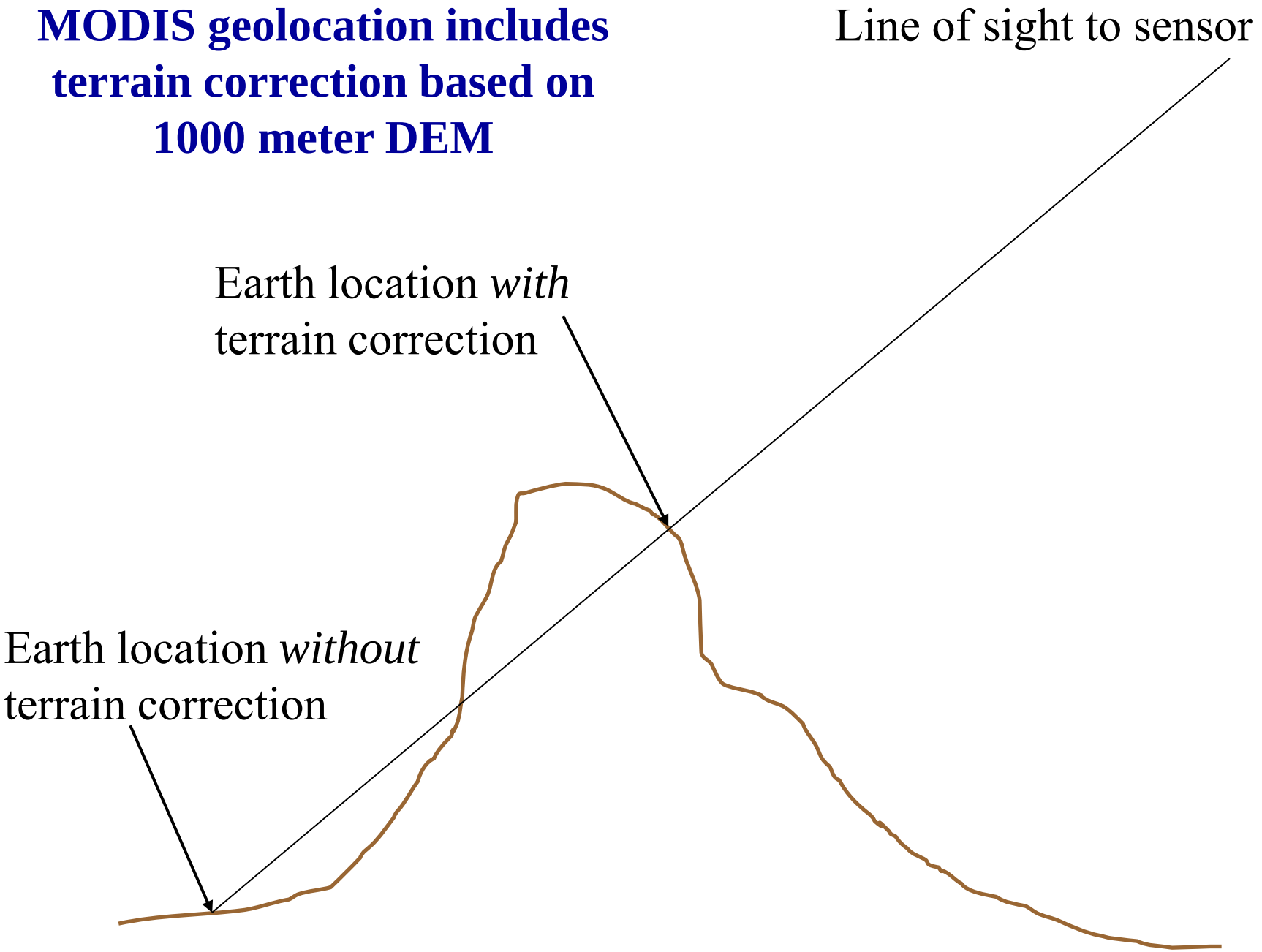
- Geodetic latitude (degrees, -90S to +90N)
- Geodetic longitude (degrees, -180W to +180E)
- Sensor zenith and azimuth (degrees, pixel to sensor)
- Solar zenith and azimuth (degrees, pixel to sun)
- Terrain height above geoid (meters)
- Land/Sea mask
  - 0: Shallow Ocean
  - 1: Land
  - 2: Ocean Coastlines and Lake Shorelines
  - 3: Shallow Inland Water
  - 4: Ephemeral (intermittent) Water
  - 5: Deep Inland Water
  - 6: Moderate or Continental Ocean
  - 7: Deep Ocean

Land-sea mask

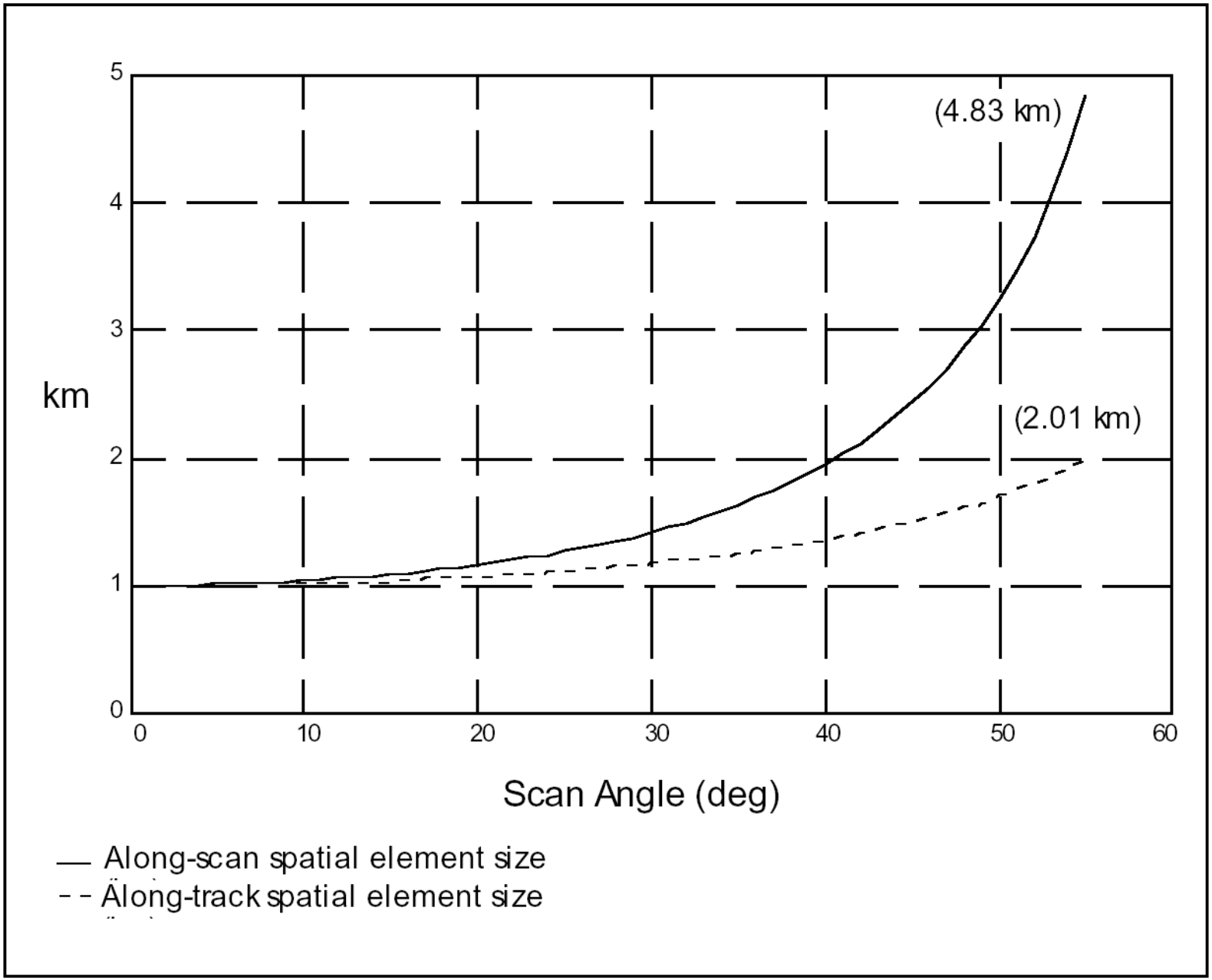


- South America inland water
- From EOS DEM SWG – best available sources

MODIS geolocation includes terrain correction based on 1000 meter DEM



Growth of MODIS 1 km pixel with scan angle



Terra Geolocation Measured RMS Error

	Update 2 – June '00 (Collection 1)	Update 3 – Feb. '01 (Collection 3)
Along Scan	58 m	56 m
Along Track	57 m	74 m
# Days	196	214
Match-ups/day	77	82

- Three Geolocation LUT updates since launch
- Nadir equivalent meters
- Update 3 vs. 2:
  - Scan direction error better
  - Track direction error worse

Realtime Geolocation

1. For realtime processing, ephemeris and attitude downlinked from spacecraft must be used.
2. Post-processed ephemeris and attitude from NASA GSFC Flight Dynamics may be used for non realtime processing (delay of at least 24 hours after data acquisition)
3. What is the impact on geolocation accuracy of realtime processing?

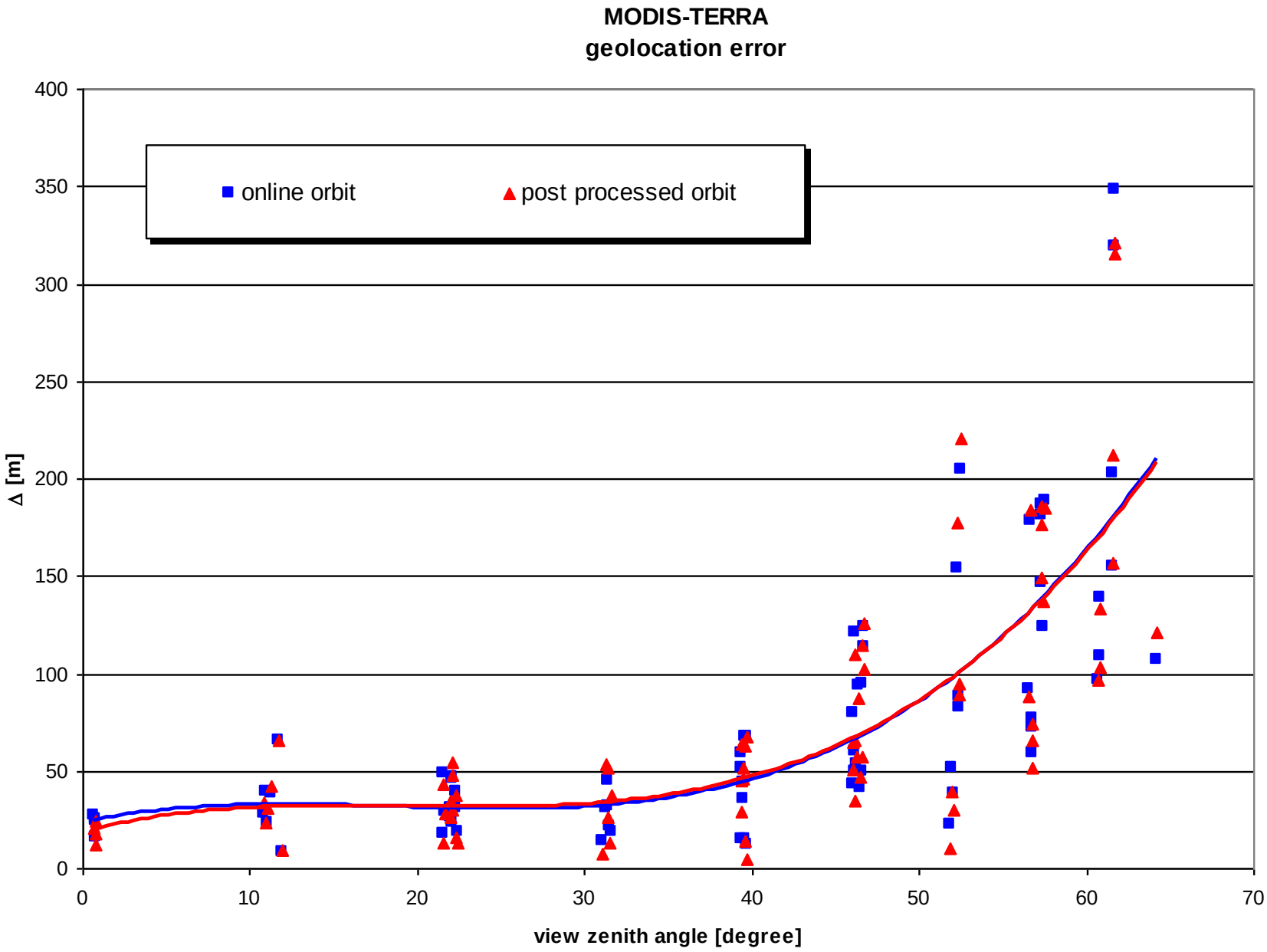


Figure courtesy of Stefan Maier, DOLA

Image Artifacts
(other than Bowtie)

Mirror Side Striping (Band 8, 0.41 μm)

Reflectance, emissivity, or polarization of each scan mirror side not characterized correctly.

Can be corrected.

Detector Difference Striping (Band 27, 6.7 μm)

Responsivity of each detector not characterized correctly.

Can be corrected.

Noisy Detectors (Band 34, 13.6 μm)

Detectors are noisy on a per frame basis and unpredictable from scan to scan.

Difficult to correct.

Saturation (Band 2, 0.87 μm)

Signal from earth scene is too large for 12 bit digitization with current gain settings.

Work around available.

Handling Saturation in Bands 1-5

Problem:

- Bright cloud tops cause bands 1-5 to saturate, and the MODIS Cloud Mask cannot process these pixels correctly. It also makes true color image creation problematic (bands 1, 4, 3).

Approach:

- Replace saturated pixels with maximum scaled integer.

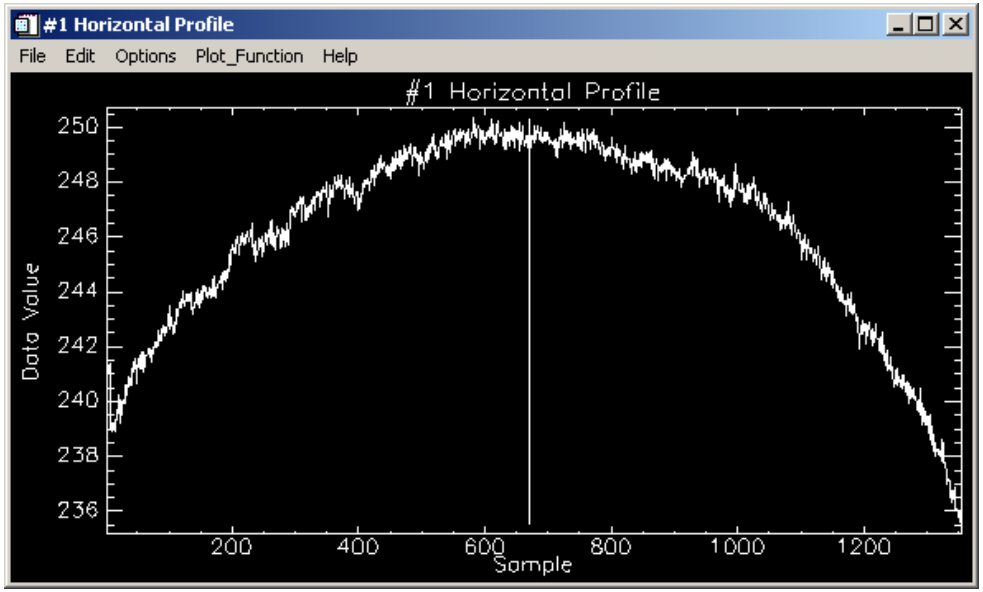
Method:

1. Check for scaled integer values corresponding to “Detector is saturated” (65533) or “Aggregation algorithm failure” (65528).
2. Replace these values with maximum allowed scaled integer (from valid_range attribute).

Response vs. Scan Angle (Band 35, 13.9 μm)

Scan mirror reflectance, emissivity, or polarization not characterized correctly as a function of scan angle.

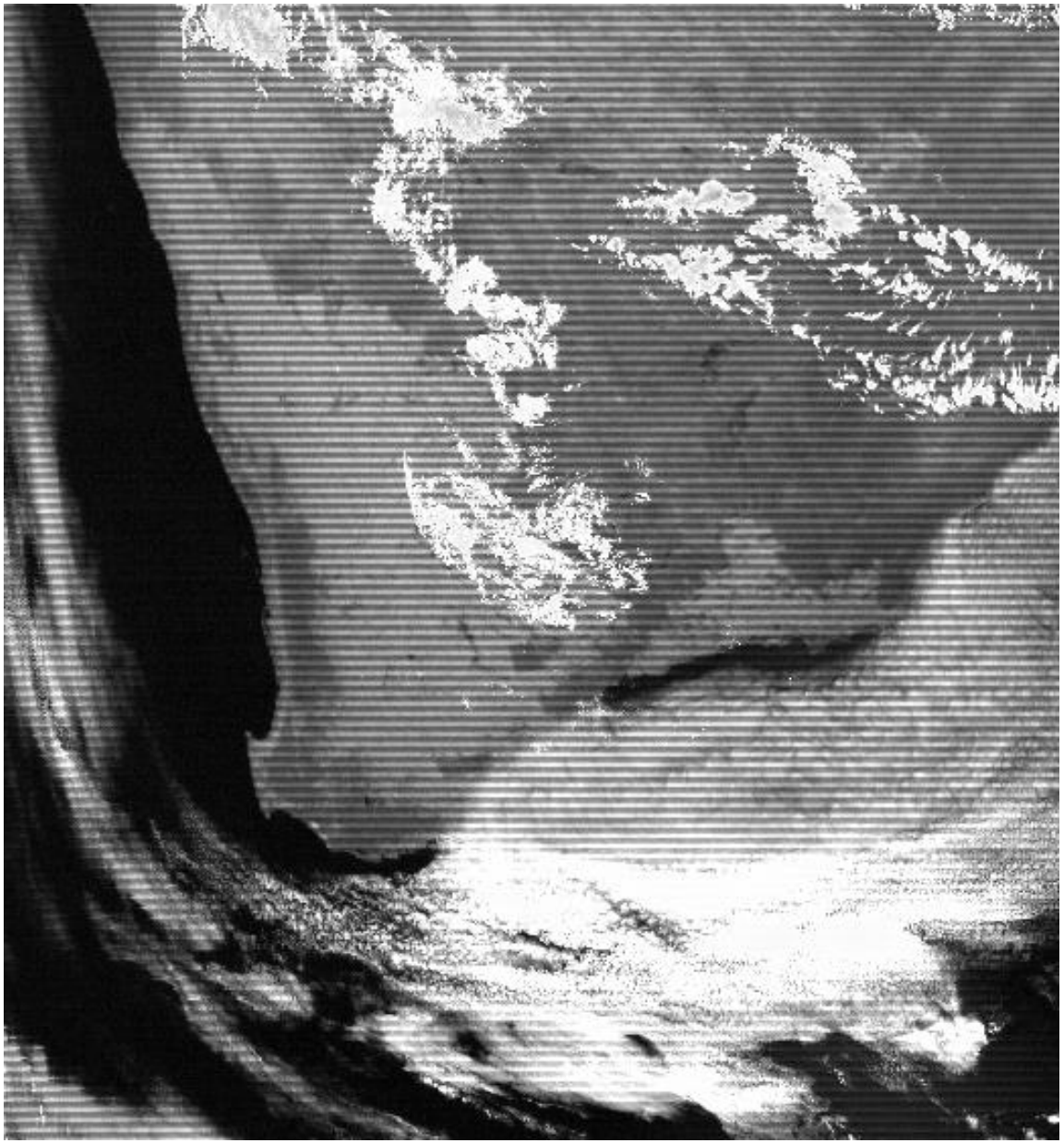
Correction is possible, but complicated.



Band 26 Optical Leak

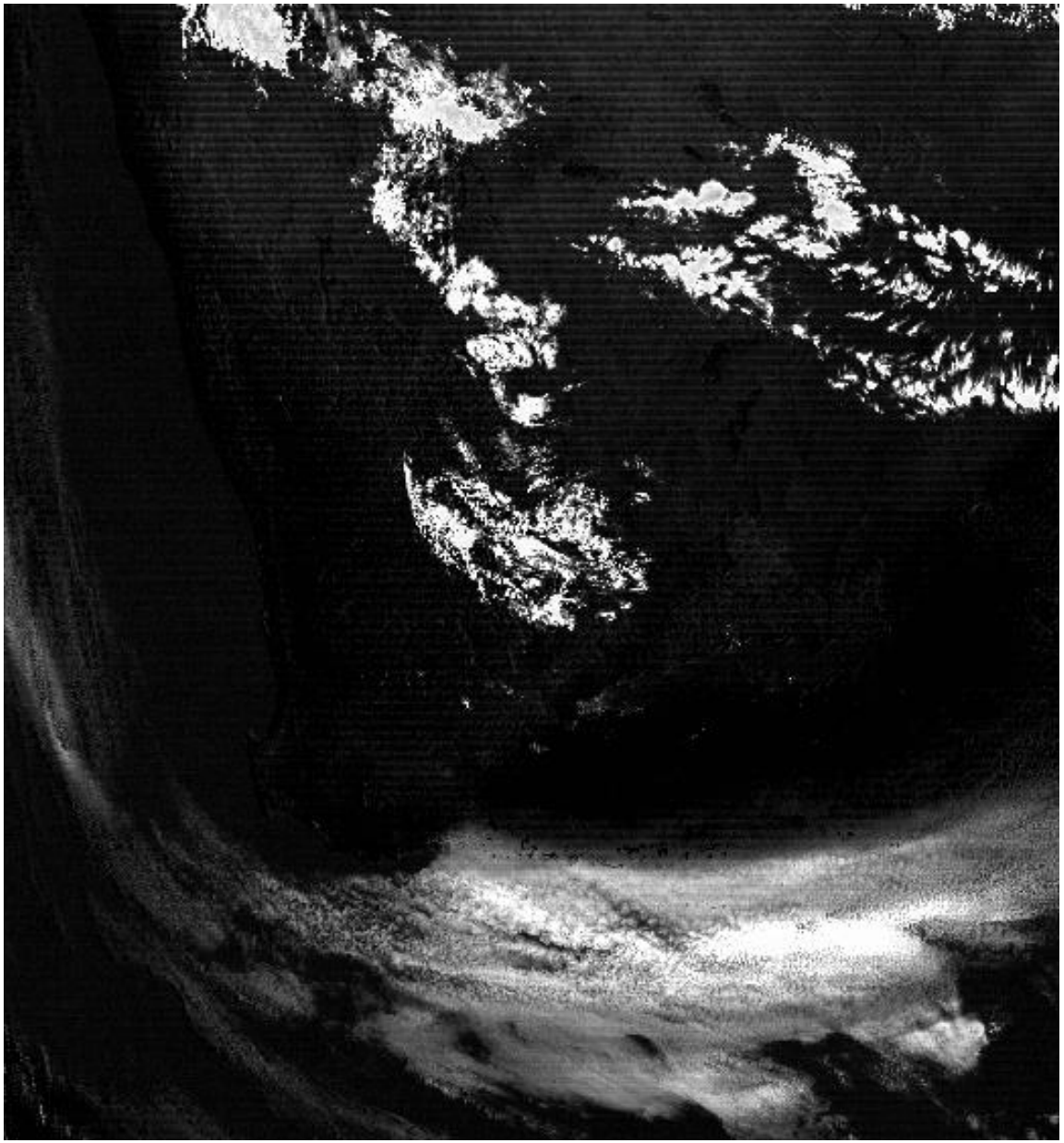
Photons intended for Band 5 detectors (1.24 μm) leak into Band 26 (1.38 μm) detectors.

Correction is operational.



Band 26 Corrected

Detector dependent correction factors remove the land surface contribution and reduce striping.



MODIS Performance

Performance Issue	Terra	Aqua
Band 26 Striping and elevated background signal	Correction in L1B now in place for Collect 4.	No Improvement Correction will be necessary
S/MWIR Electronic Crosstalk	An ongoing issue No on-orbit correction	Improved (reduced but not eliminated)
PC LWIR Band Optical Leak	Corrected in L1B; 1-2% uncertainty	Fixed during prelaunch
Detector Striping	Exists in several thermal IR bands	Improved

MODIS Performance
cont.

Performance Issue	Terra	Aqua
5um thermal leak into SWIR	Small influence; Effectively Corrected in L1B	Improved; Correction in L1B TBD
SWIR Band Subsample Departure	On going issue No on-orbit correction	Much Improved
Noisy Detectors	Several in LWIR CO2 bands, one in B24, 25, 27, 28,30	Much Improved (B36 chan 5)
Saturation in Band 2	Saturation on thick water cloud, sunglint regions	Slightly Worse (lower saturation level)

MODIS Performance
cont.

Performance Issue	Terra	Aqua
Scan Mirror reflectance vs. angle of incidence	Ongoing issue.	Much Improved Good prelaunch characterization
Dead detectors in SWIR bands	None	B6 severely impacted; B5 has one dead detector

Destriping

MODIS LWIR Destriping Investigation

LWIR L1B image artifacts are introduced by:

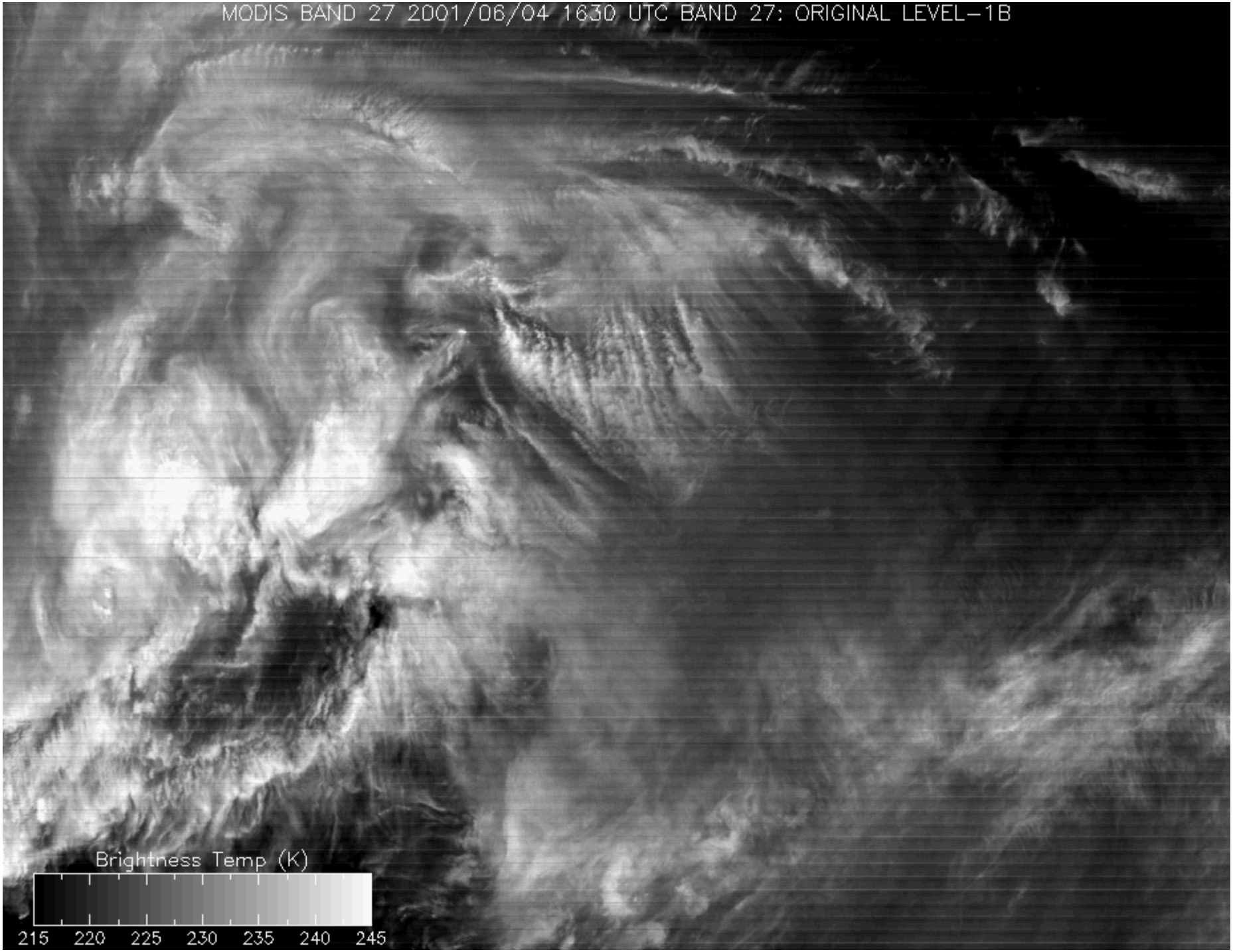
- Mirror sides not characterized perfectly
- Detectors calibrated independently
- Detectors "out of family”

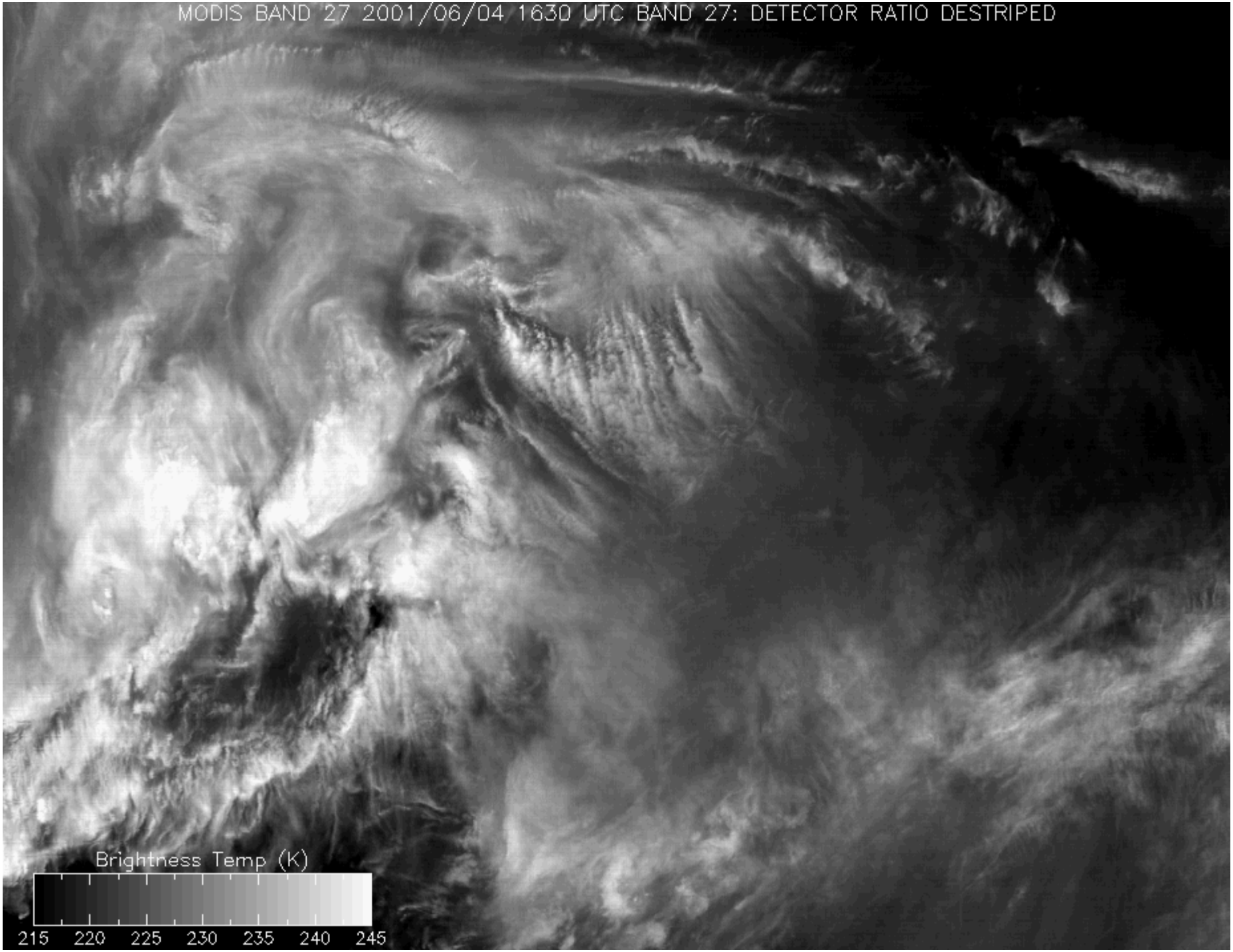
For all MOD021KM granules on 2001/06/04, extracted successive 100 x 100 boxes of pixels at nadir (5760 samples), and for each box computed (in radiance units):

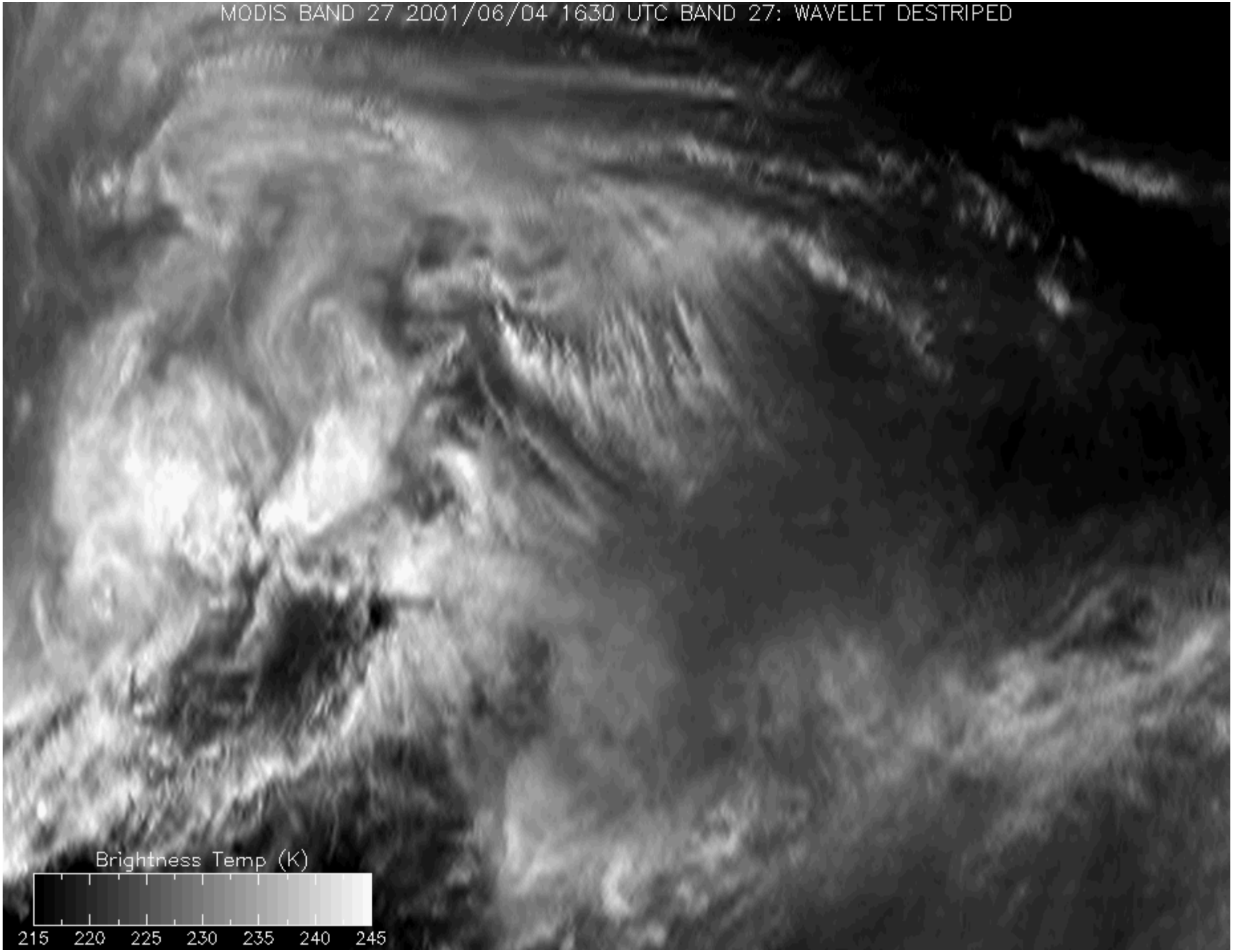
- Overall mean and standard deviation
- Mean and standard deviation for each mirror side
- Mean and standard deviation for each detector

For uniform boxes (low standard deviation):

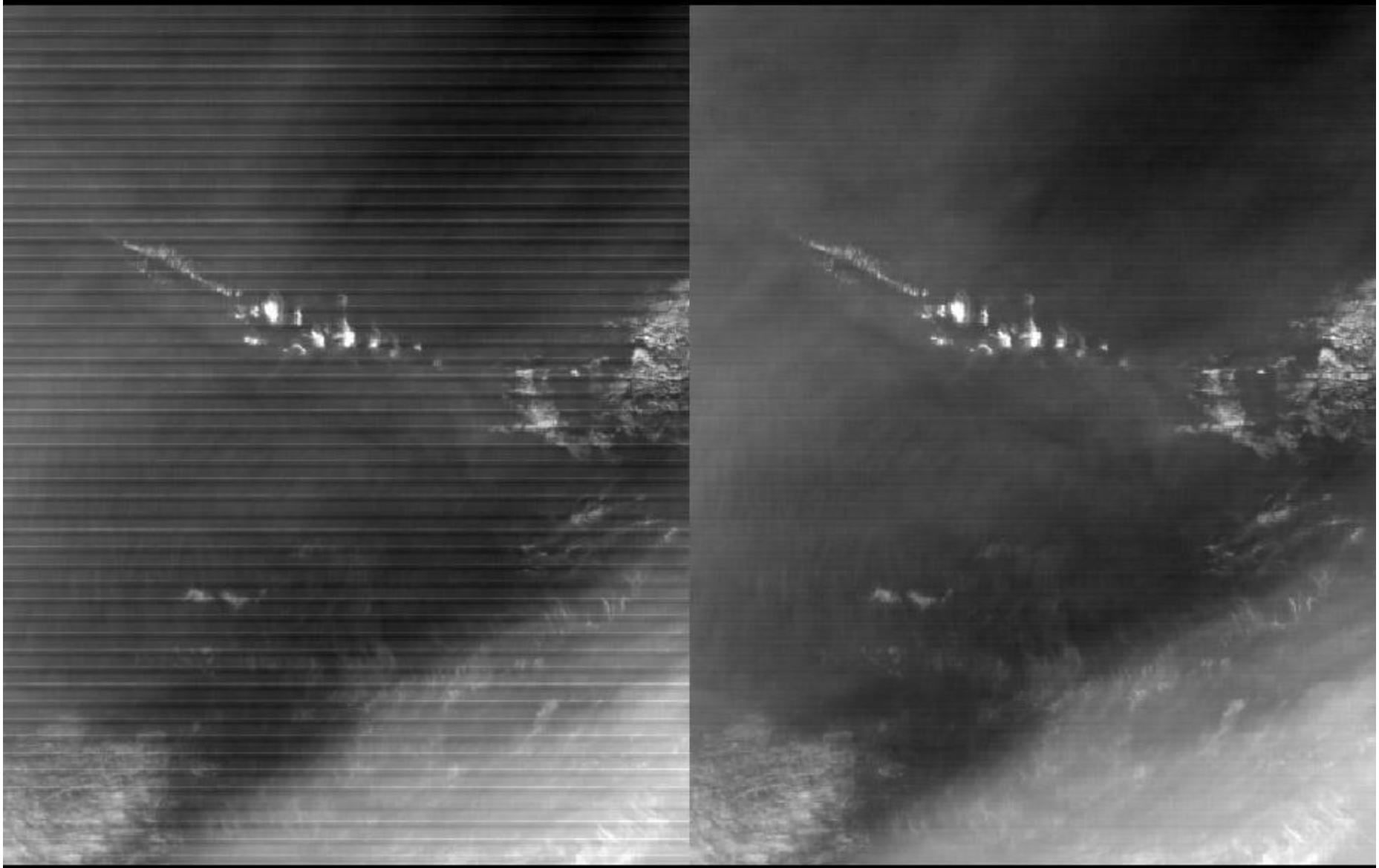
- Selected reference detector
- Computed ratio of each detector to the reference


MODIS BAND 27 2001/06/04 1630 UTC BAND 27: ORIGINAL LEVEL-1B
Brightness Temp (K)
215 220 225 230 235 240 245


MODIS BAND 27 2001/06/04 1630 UTC BAND 27: DETECTOR RATIO DESTRIPED
Brightness Temp (K)
215 220 225 230 235 240 245


MODIS BAND 27 2001/06/04 1630 UTC BAND 27: WAVELET DESTRIPED
Brightness Temp (K)
215 220 225 230 235 240 245

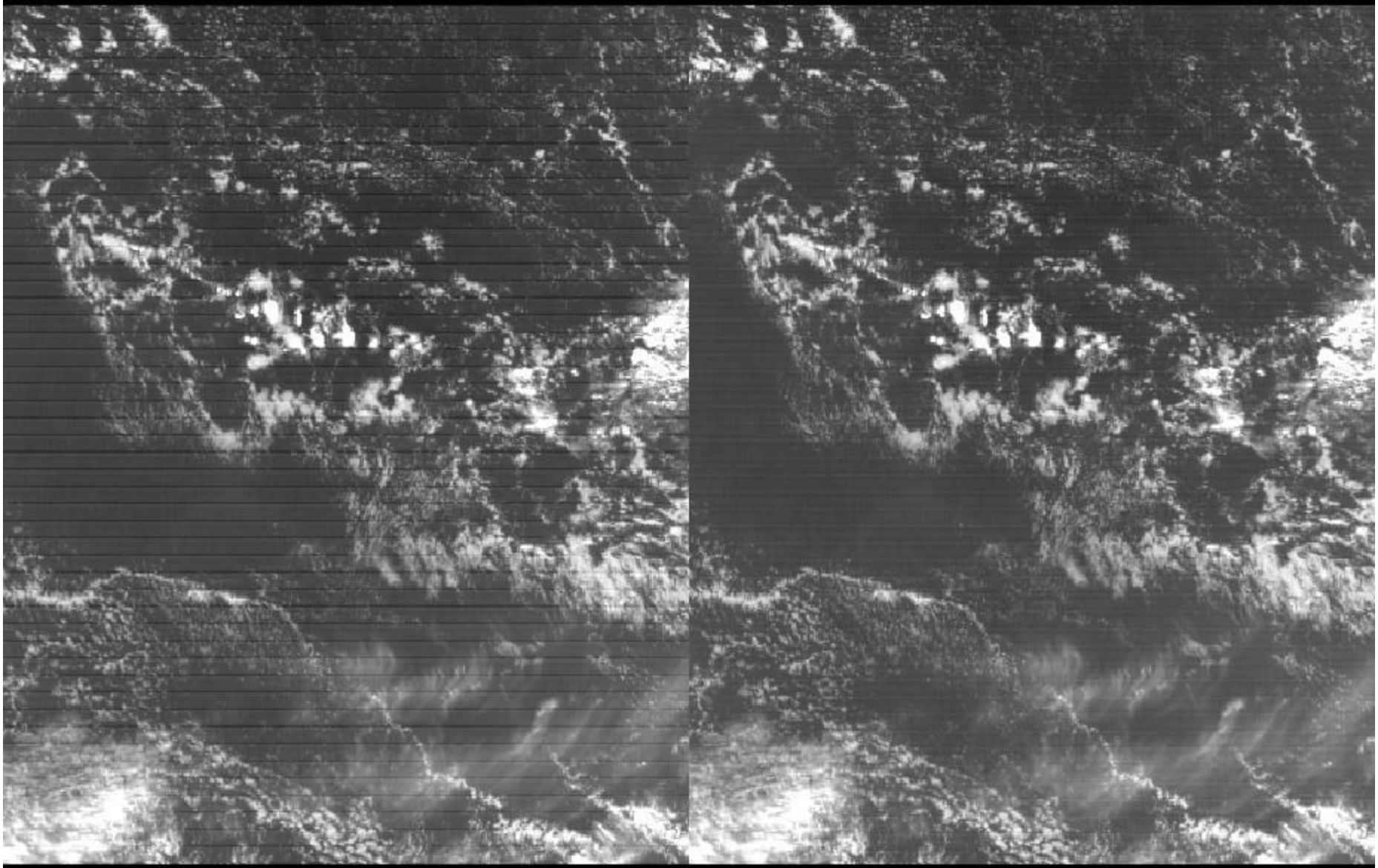
MODIS Band 27 (6.7 μm), 2001-06-04 16:45 UTC



Original L1B (V003)

Destriped

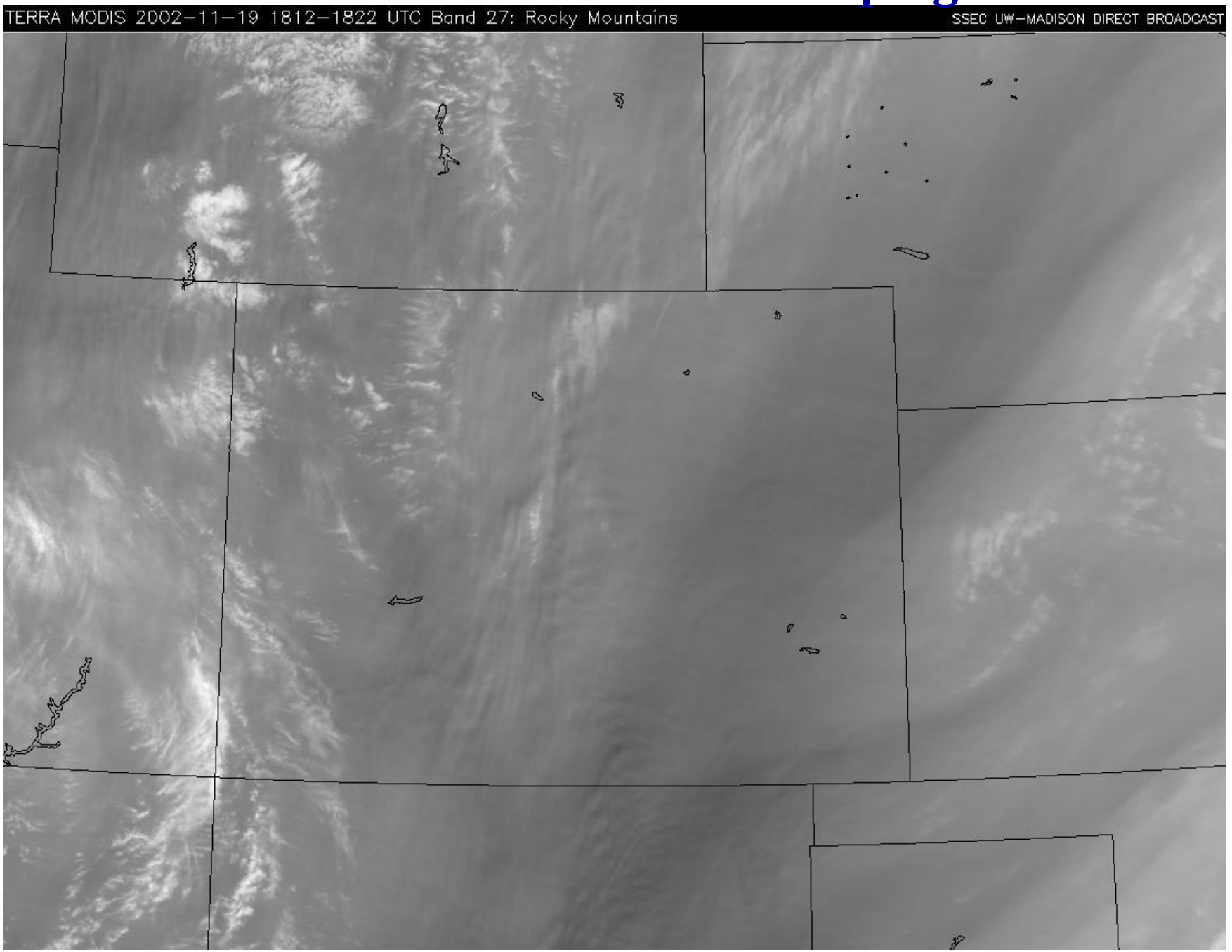
MODIS Band 30 (9.6 μm), 2001-06-04 16:45 UTC



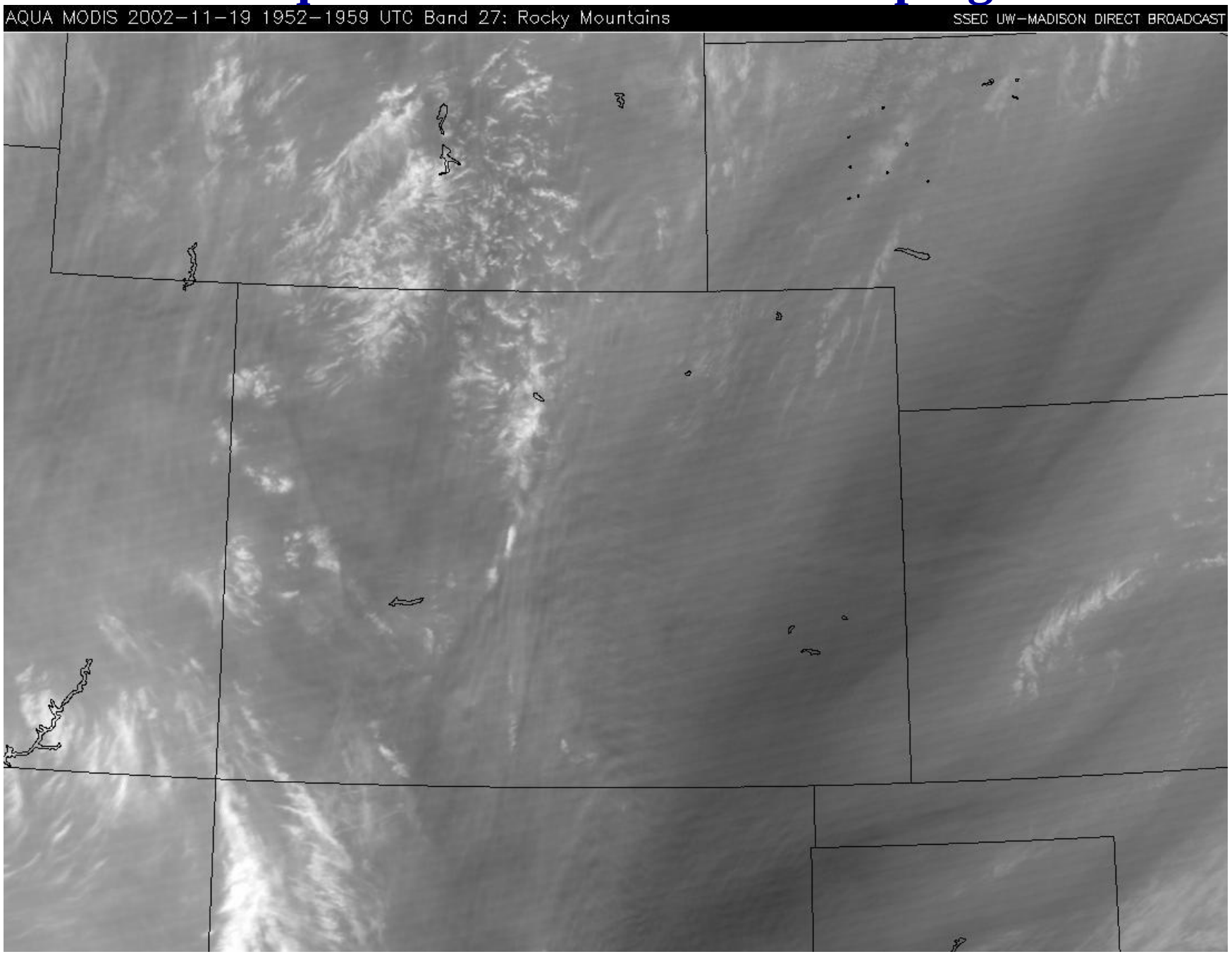
Original L1B (V003)

Destriped

Terra MODIS with Destriping



Aqua MODIS without Destriping



MODIS LWIR Destriping Challenges

Time dependence:

- Corrections for Jun. 2001 do not work as well in Dec. 2000
- Need to analyze a series of months to ascertain time dependence

Dealing with remaining artifacts:

- Bands dominated by noise (e.g. band 34) require image processing
- Some detectors must be replaced (replicate or interpolate?)
- Need to investigate scene dependence of detector ratios (currently assume same correction applies for all scene temperatures)

Real-time monitoring:

- Implement destriping corrections on UW direct broadcast data, based on analysis on latest 7 days of overpasses
- Allows monitoring of changes in detector corrections over time