On-orbit Characterization of the Dependence of VIIRS Thermal Bands Noise on Cold FPA Temperature

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Introduction

• VIIRS (Visible-Infrared Imaging Radiometer Suite) instrument onboard the Suomi NPP (National Polar-orbiting Partnership) spacecraft has been operating on orbit for close to four years by now

• Throughout this time temperature of the VIIRS cold FPA (focal plane array) has remained remarkably stable near 80 K

• Two exceptions when elevated cold FPA temperatures were observed were the period before complete activation of the cryoradiator and the brief time during an orbital pitch maneuver

• Dependence of the VIIRS TEB (thermal emissive band) noise on the cold FPA temperature was measured using onboard calibrator data acquired during these occurrences

• The measurements enable answer the still hypothetical question about SNR changes were the cold FPA temperature to increase from 80 K to 82 K

• This analysis also helps NOAA users better understand requirements for the JPSS-1 and future VIIRS instruments
Long-Term Stability of Cold FPA Temperature

Graphs from the NOAA STAR ICVS long-term monitoring

LWIR

SWIR/MWIR

Scan UTC Date
Initial FPA Cool-down and SNR Recovery

Based on noise in VIIRS measurements of BB radiance: mean and standard deviation of 48 samples from each scan.

Stable blackbody temperature

Cool-down after opening of the cryoradiator door

All detectors are shown; each with a different color, to display consistency between the detectors.
SNR during Pitch Maneuver

For MWIR bands, SNR is stable since FPA temperature remains well below 120 K.

For LWIR bands, SNR initially drops with increasing FPA temperature, and then recovers after the cool-down.

Stable blackbody temperature

Warm-up and cool-down during the maneuver
SNR at Temperature of 80-82 K: Initial Cool-down

Using spline interpolation to compare SNR between 82 K and 80 K

Cyan line shows SNR averaged over one orbit (for single detector)
Although temperature decreased a little faster during the pitch maneuver, the SNR results are very similar to those from the initial cool-down.
Conclusions

- Two independent measurements of VIIRS TEB SNR dependence on cold FPA temperature were conducted on orbit:
  1. During initial cool-down after the cryoradiator door opening
  2. During an orbital pitch maneuver
- There is a very good agreement between these two measurements

<table>
<thead>
<tr>
<th>Band</th>
<th>SNR Reduction 82 K vs. 80 K (%)</th>
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<tbody>
<tr>
<td></td>
<td>Initial Cool-down</td>
</tr>
<tr>
<td>M14</td>
<td>14 ± 2</td>
</tr>
<tr>
<td>M15</td>
<td>6 ± 1</td>
</tr>
<tr>
<td>M16</td>
<td>11 ± 1</td>
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</tbody>
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- Dependence of the VIIRS TEB noise on the cold FPA temperature was measured using onboard calibrator data acquired on orbit
- The on-orbit measurements have enabled prediction that if the cold FPA temperature were to increase from 80 K to 82 K, noise in the VIIRS LWIR (long-wave infrared) bands, M14, M15, and M16, would increase by no more than 15%
- Since large margins exist between the current VIIRS noise performance and the product requirements, such an increase, although not negligible, would still be acceptable for measurements of sea surface temperature and cloud top properties
- Nevertheless, it will be beneficial if the VIIRS cold FPA temperature remains unchanged for the next several years of the Suomi NPP mission