J1 VIIRS DNB Unique Features

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• Cause: J1 DNB radiometric nonlinearity
• Mitigation: remove DNB agg mode with severe nonlinear behavior
  – J1 Op21: J1 DNB Aggregation Option 21
  – J1 Op21/26: J1 DNB Aggregation Option 21/26
  – NPP vs. J1 options
• Impact:
  – Imagery
  – Calibration
J1 DNB Aggregation Options

Simulated DNB EV pixel growth based on nominal parameters
J1 DNB Options EV Extent

Simulated DNB EV data extents

Reduced resolution at high scan angles
Increase coverage overlaps: successive scans: Bowtie successive orbits: EOS/BOS

J1 DNB EV Extended pixels can be turned on/off by LUT updates
J1 DNB Options EV Extent
DNB SNR: NPP vs. J1

- J1 DNB Options vs NPP at high scan angles:
  - lower spatial resolution
  - higher SNR

NPP on-orbit estimated SNR

J1 pre-launch estimated SNR
SDR Calibration: J1 Options

\[
L = (DN - DN0) \times DNB_{\text{Coef}} \times DNB_{\text{RVF}}
\]

- **DNB Frame_to_zone**
  - Define EV pixel DNB aggregation mode

- **DNB_DN0**
  - EV pixel based offset

- **DNB_DN0_sat**
  - (Uploaded) on-board EV pixel based offset

- **DNB_RVF**
  - EV pixel based RVS

- **DNB_Dark_signal_ref**
  - OBC mode based offset

- **DNB_Moon_illumination**
  - Moon illumination used to select OBC dark data

**DNB_LGS_Gain, DNB_Gain_Ratios**

* DNB Option specific LUT needed
DNB On-Orbit Cal & SDR

- Three gain stages
  - LGS gain:
    - SD during Solar Calibration
    - SD vs. EV gain at SD cal?
    - EV gain linearity?
  - MGS and HGS gain:
    - Gain transfer using transitional signal (Xcal)
    - MGS = LGS * MGS/LGS
    - Gain ratios determined by EV vs. SD?
- Nonlinearity
  - $dn_{xcal}$: Xcal
  - $dn_{image}$: SDR & Xcal
- Current Cal: linear gain
- What is the impact of nonlinearity on SDR calibration?

LGS

MGS

HGS

$dn_{image}$

SDcal

$dn_{xcal}$

Xcal

L_max

Day

Transition

Night

L_min
**DNB LGS Characteristics**

- Normalized EV (pixel) and SD (mode) gain
- Some LGS detectors show different response behavior among pixels within the same agg mode
- Nonlinear: sample dependent, worse at lower dn
- The gain is more linear in SD than EV
- SD ~ EV gain at Solar Calibration
- Nonlinearity above Lmin (small): imagery
- **Nonlinearity below Lmin (large): Xcal**
- Mode based calibration can not resolve nonlinearity at sample space?
**DNB MGS/HGS**

- Normalized EV (pixel) and SD (mode) gain
- SD ~ EV gain
- No EV sample dependency as observed in LGS
- SIS radiance uncertainty: discontinuity in MGS due to bulb change
- Uncertainty in determine HGA low dn radiance

Difficult to conclude the severity of MGS and HGS nonlinearity
**EV vs. SD**

- **EV vs. SD for each DNB mode/det**
  - Solar Cal (LGS)
    - EV gain ~ SD gain, few detectors/mode has up to 3% differences
  - Xcal
    - LGS/MGS: some mode/det has large SD/EV difference

**Uncertainty:**
- Few calibration view samples
- Limited dn levels in Xcal
SDR Impact

Calibrated/measured Gain
Top: Xcal by EV data
Bot: Xcal by SD data

Horizontal striping
• Cross detector variation

Vertical striping
• Cross mode variation

Additional uncertainty from HGS nonlinearity
Summary

• J1 DNB aggregation options
  – No change for scan angle within ~50 degree of nadir
  – Use mode 21 (Op21) or mode 21/26 (Op26) from ~50 to EOS.

• Impact on Imagery
  – Pixels at high scan angle will have reduced spatial resolution, higher SNR
  – Larger EV extent, increase overlaps

• Impact on Calibration
  – Some LUTs will need to be J1 Option specific
  – The nonlinearity could have significant impact on nighttime SDR due to gain ratio biases
  – The calibration bias could cause horizontal/vertical striping in DNB nighttime images due to detector/sample gain dependency

• Needs further investigation after J1 launch
  – Gain ratios computed using EV vs. SD data
  – EV sample dependency
  – Algorithm change: Sample base cal, quadratic fit.
backup
J1 DNB Extended EV

**BOS:**
- NPP: -56.06°
- J1 Ops: -56.27°
- Op21 Extended EV samp: 8 (mode 32) + 8 (mode 21)
- Op21/26 Extended EV: 8 (32) + 10 (26)

**EOS:**
- NPP: -56.06°
- Op21: 60.52°
- EV Extended samp: 288 (21)
- Op21/26: 57.58°
- EV Extended samp: 131 (26)

Option of setting as fill values in SDR through LUTs (Tested)

Significant pixel growth and bowtie effect at extreme angle
- RTA fixed, staring at SIS100
- 27 source levels to cover from the DNB dynamic range
  - 3 collects at each level: Attenuator (in/out), dark
- Staring at the same source output
  - All DNB EV samples (aggregation modes) are recorded
  - All calibration views (SV/BB/SD) are recorded, DNB modes cycled from 1-36
  - All DNB gain stages are recorded
- Enable single source comparison for all DNB modes/stages/detectors
Test Data: TV Hot Op21

- TV_Hot_Op21: HGA example
- Characterize EV per DNB sample
- Characterize EV/Cal View per DNB mode
- Cross examination of EV/Cal View behavior
- Cross-stage calibration (Xcal)
- Assess operational calibration strategies
SDR Impact Analysis

• Compute EV gain: per sample/mode
• Compute SD gain: per mode
  – Gain = dn/L_{SIS} (linear)
• Compute the calibrated DNB gain using the measured LGS gain and gain ratios
  – EV vs. SD at SD calibration
  – EV vs. SD gain ratios
• Compared calibrated vs. measured HGS gain
  – Calibration impact on nighttime SDR
SDR Impact

- Calibrated vs. measured HGA gain
- EV\_xcal: LGS*EV\_xcal
- SD\_xcal: LGS*SD\_xcal
- EV\_xcal: some mode/detector show large biases due to LGS nonlinearity
- EV pixel based Xcal can’t solve the issue
- SD\_xcal: more spread (fewer data points), fewer outliers
DNB Mode 3, Detector 1

- MGS/LGS gain ratio spread
- LGS responses have a dip in the last 8 samples
- MGS dn consistent
- The last 8 EV samples and SD are more linear and better for Xcal
Non-linearity: R & D

- MGS/LGS gain ratio not consistent over EV sample and radiance level
- LGS: higher last 25 samples
- MGS: consistent
- LGS gain: last 25 samples are in-family with the mean and SD gain
- Non-linearity only in certain samples
- Cal method (Code) change required to address this
- On-orbit update?