Latest update on J1 VIIRS geolocation

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- Thanks to the NASA VIIRS Land SIPS Team for processing control point residuals in forward-&re-processed VIIRS geolocation products, and testing Geo LUTs updates.
- Thanks to the JAM, Rosalie Marley, for helping us resolving DRs in the DPE/AMP/GRAVITE.
- Thanks to NOAA JPSS MOT, NASA FDF, BATC for assistance in understanding the SNPP orbit dynamics and attitude issues.
- And thanks to other members of the JPSS family… …

Outline

1. J1 updates from SNPP VIIRS geolocation
   - Mounting matrix & possible on-orbit correction
   - Differences from SNPP
     - LSF/FOV, BBR, focal length, scan rate
     - DNB – thanks to STAR colleagues for code update
2. SNPP updates for J1 VIIRS geolocation
   - Improvements completed
   - Improvements in the making
3. Concluding Remarks

- Extra: Posters 1) J2 VIIRS test data analysis results
  2) On-Orbit Measurement of the Focal Length of the SNPP VIIRS Instrument

Part 1: J1 updates from SNPP VIIRS geolocation

- Mounting matrix & possible on-orbit correction
- Differences from SNPP
  - Optical performance, BBR
  - Focal length, scan rate, scan-to-scan underlaps
  - DNB geolocation with options in reduced aggregation mode – thanks to STAR colleagues for code update

J1 Post-vibe, PreTV data from BATC report

IMF Delta from Average (arcsec)				+0G			
	Bias	VIIRS	ATMS	CrIS	CERES	OMPS	Average-bias
ΘX		17.5	-94.1	47.9	10.9	18.0	49
ΘY		41.6	-11.0	66.0	-70.5	-27.8	-600
ΘZ	-50	-51.8	180.6	3.1	-260.6	-123.4	-202

- Mounting coef T_inst2sc =

```
 0.99999997 0.00019698  0.00015131
-0.00019698 0.99999998 -0.00005173
-0.00015132 0.00005170  0.99999999
```

Equivalent to Euler angle correction (arcsec)

Angle	At-launch	Measured Delta
Yaw	40.6, postTV?	?
Roll	-10.7, postTV?	?
Pitch	-31.2, postTV?	?

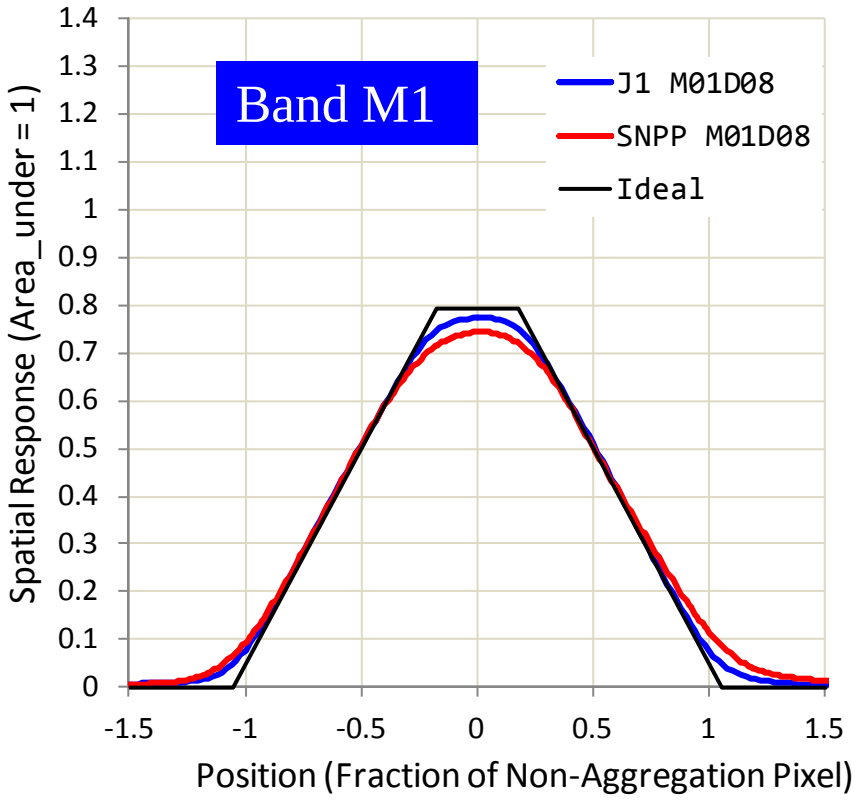
SNPP initial on-orbit geolocation correction

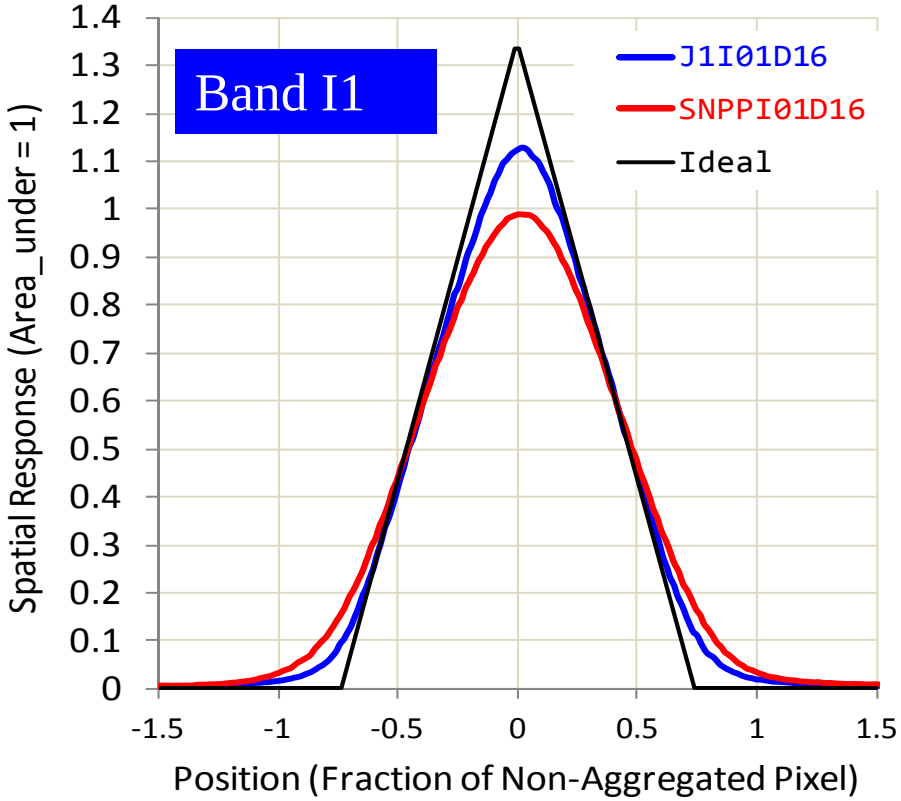
Correction to Instrument to Spacecraft Alignment (arcsec)

Angle	At-launch	Measured Delta
Yaw	33.2	62.2
Roll	41.2	-268.5
Pitch	-59.3	212.5

Nadir equivalent:
Δtrack -775 m,
Δscan 1,118 m

Optical calibration – Scan LSFs

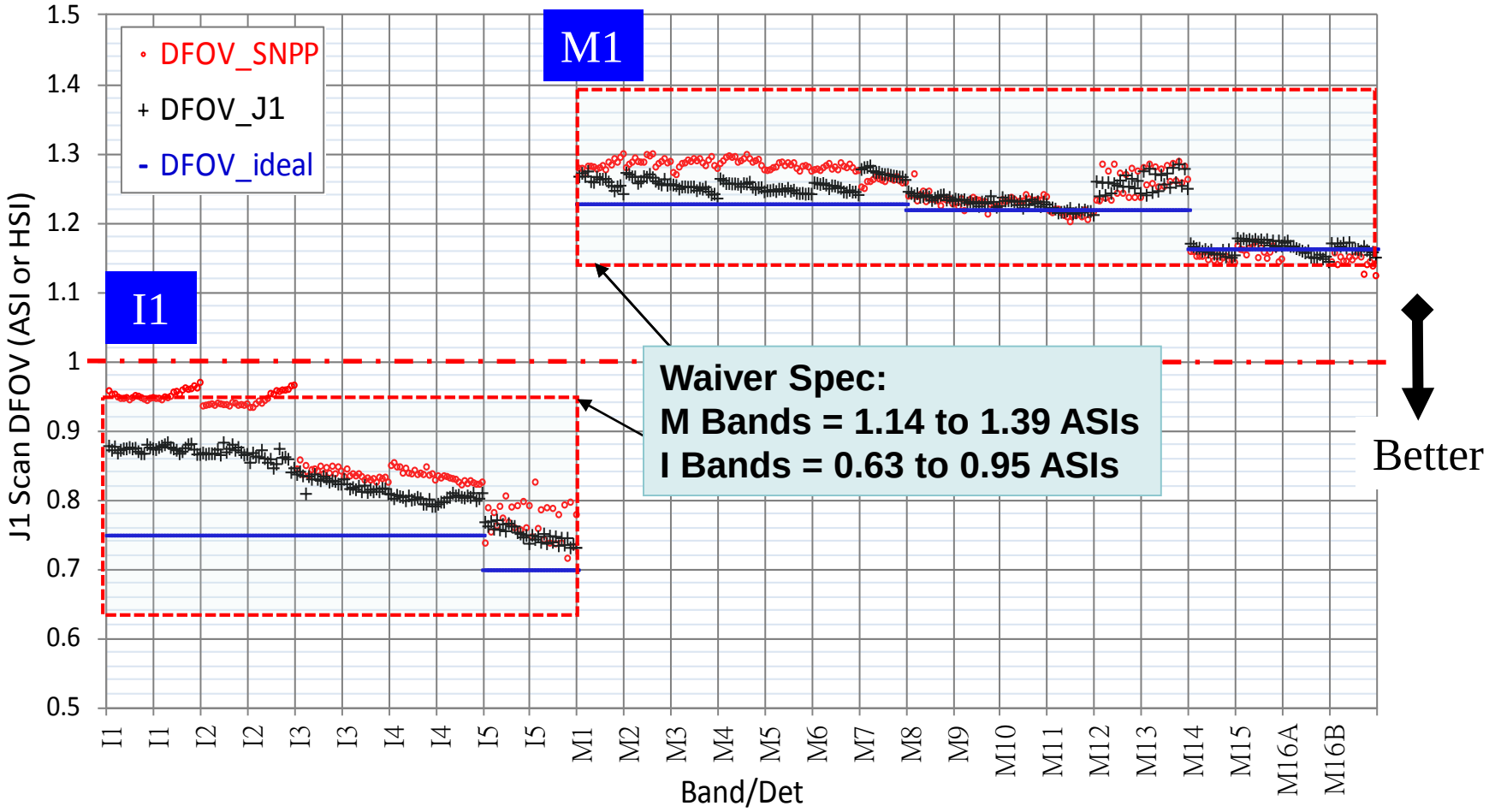




- J1 VIIRS has improved optical performance over SNPP, which shows up in band I1 LSFs more prominently

LSF = Line Spread Function

Scan LSF → DFOV(Dynamic Field Of View)

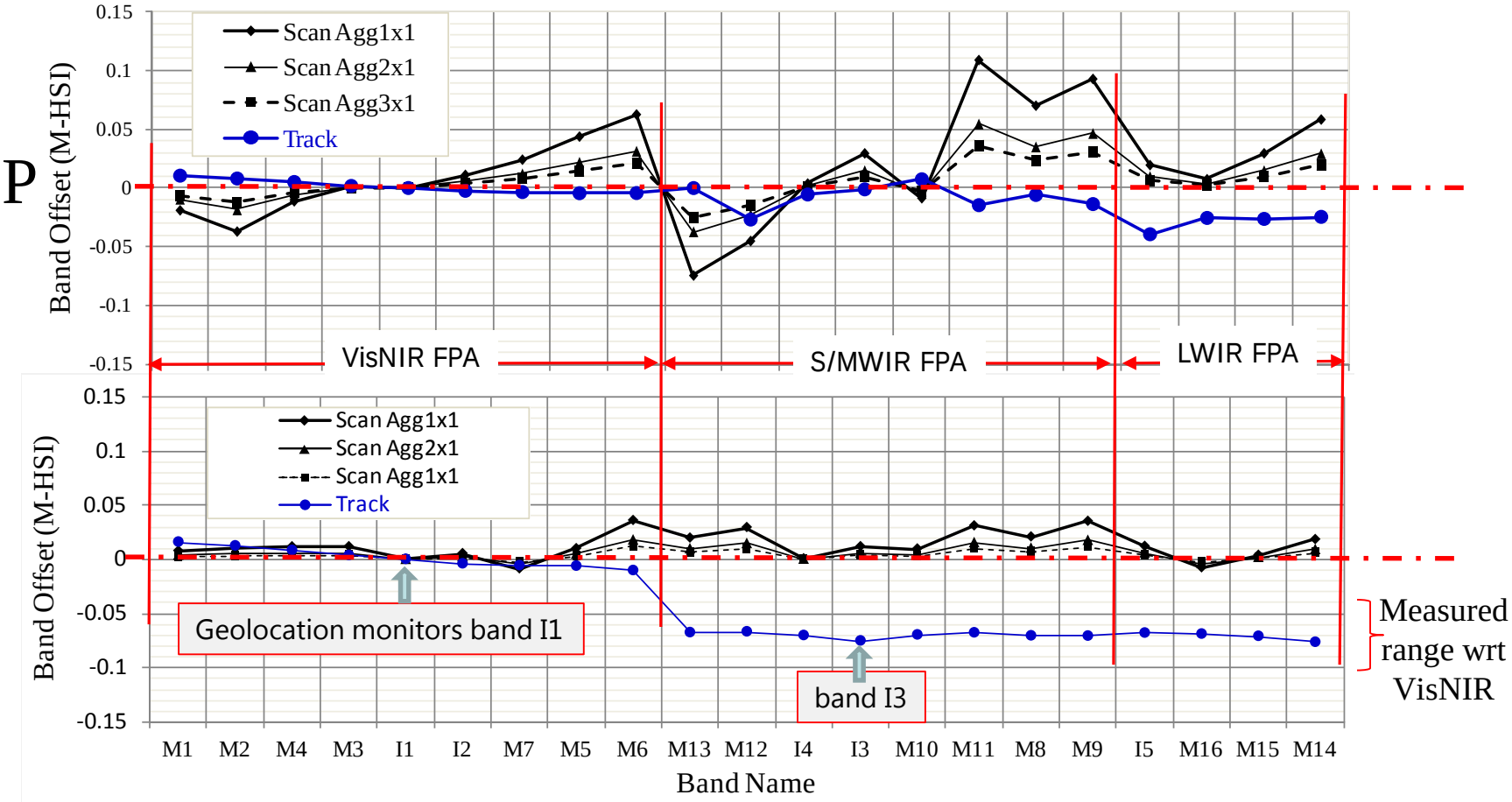


- J1 VIIRS has better focus while SNPP VIIRS has de-focus in VisNIR bands
  → a "trade" in focal length : scan rate : scan-to-scan underlap
- I-bands under-sample while M-bands over-sample the earth in the un-agg zones

BBR: M/I band offsets wrt I1

SNPP

J1



- J1 BBR performance is better than SNPP BBR in the scan direction
- In the track direction, J1 Bands on cold FPAs shifted ~ 50 m from bands on VisNIR FPA.
- Additional geolocation monitoring of band I3 is planned to monitor the shift

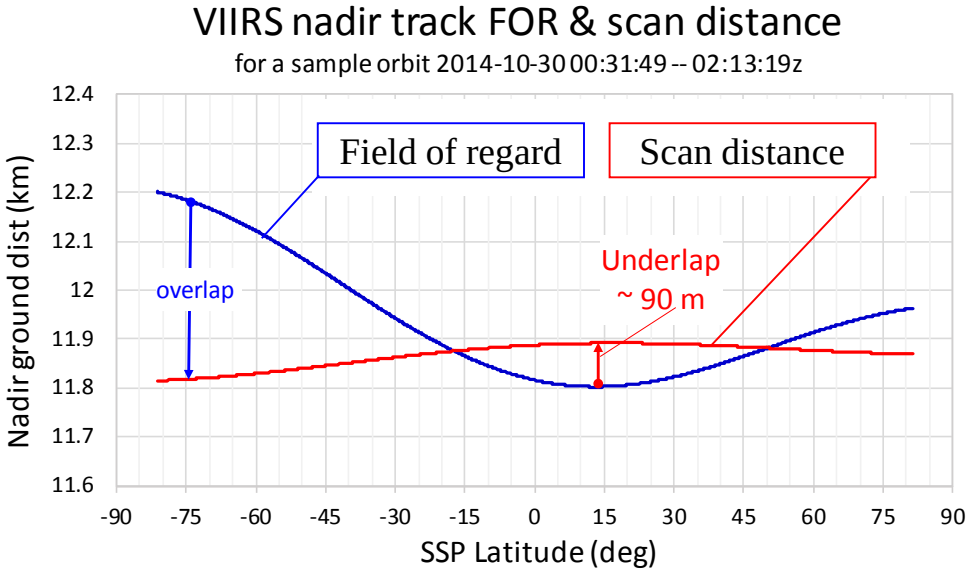
Focal length, scan rate (1/2)

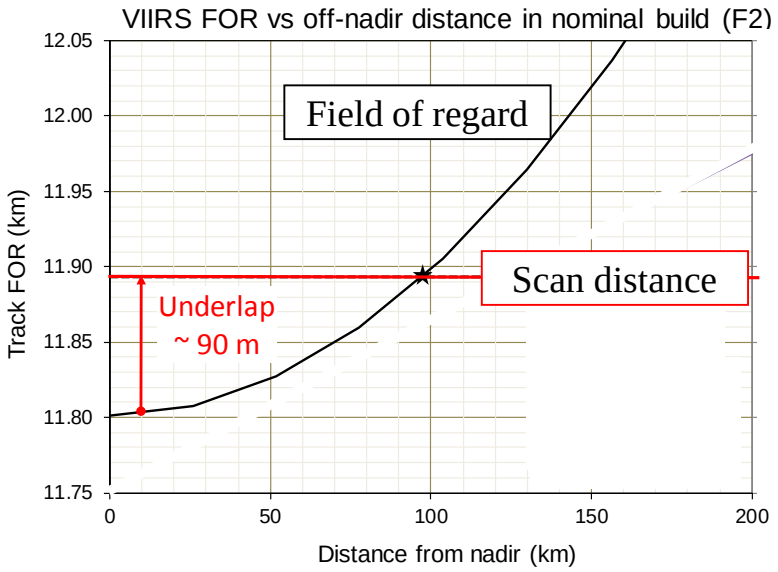
	EFL (mm)	Scan rate (rad/s)	Scan period (s)	EV scan angle (deg)	EV ground distance (km)
SNPP	1135	3.531	1.7793	+/- 56.28	+/- 1528
J1	1141	3.517	1.7867	+/- 56.04	+/- 1510

- Focal length affects scan rate per BBR requirements
- SNPP focal length is too short so that the scan rate is maxed out (+0.4%)
  - On-orbit measurement for SNPP EFL is ~ 0.5% shorter than nominal, see poster
- J1 focal length is nominal, which will be assessed on-orbit

Focal length, scan rate (2/2)

- J1 VIIRS built to nominal optical performance results in unexpected scan-to-scan underlap[1,2]





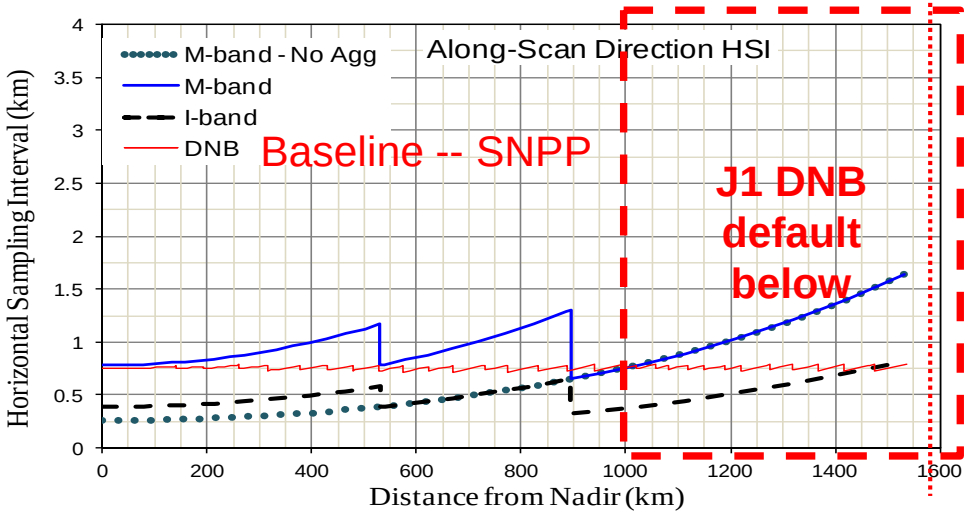
- Largest underlap occurs at nadir and ~15^{o} N in the ground track
- Higher terrain opens up underlap more, ~ 14 m/km terrain height
- Spacecraft jitter makes underlap more in one scan but less in the next

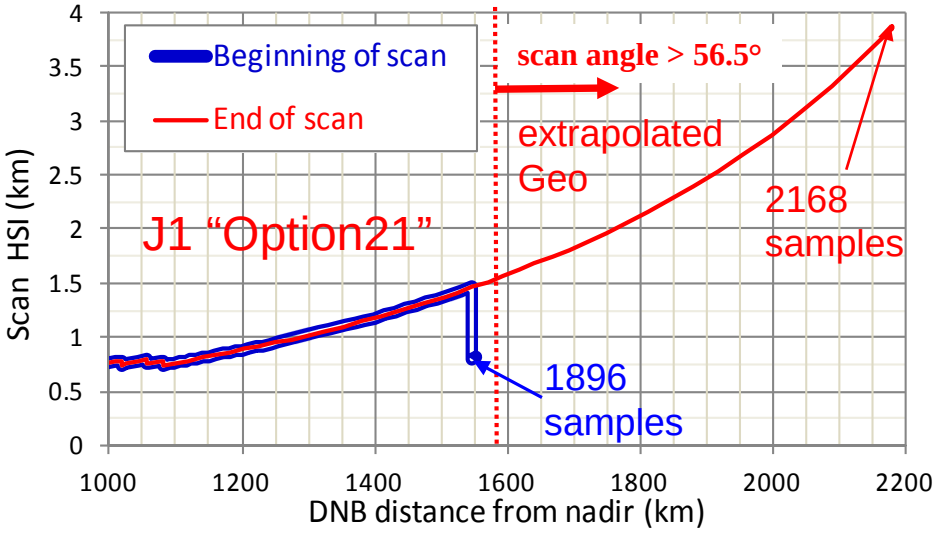
1. Lin, G., R.E. Wolfe, J. C. Tilton, (2016),"Trending of SNPP ephemeris and its implications on VIIRS geometric performance", Proc. of SPIE, Vol. 9972, 99721K, doi: 10.1117/12.2239043.

2. My eRooms > JPSS Science > J3-J4_VIIRS_Performance-Improvement > JPSS Orbit Parameters and Variations

J1 DNB aggregation mode change

-- Thanks to STAR colleagues for code update





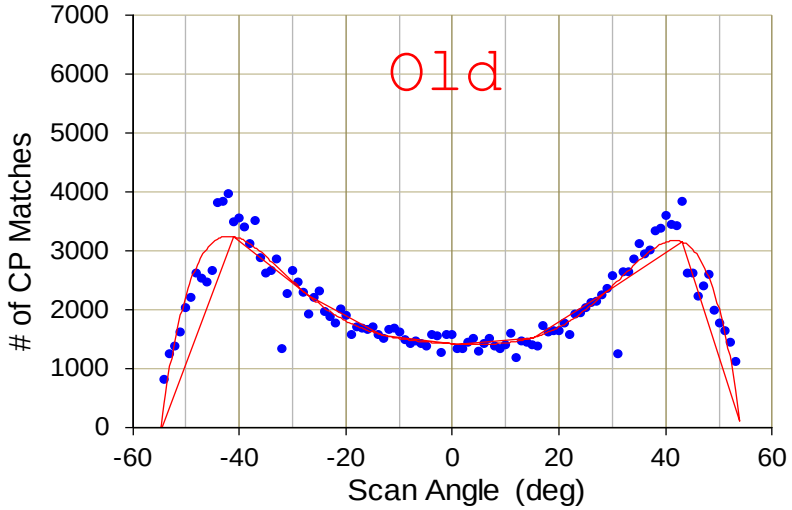
- SNPP baselined pixel size is ~ 750 m
- J1 "Option21" has pixel size growing larger to the end of scan
- Geolocation is extrapolated (no encoder data) post-nadir for scan angle > 56.5°

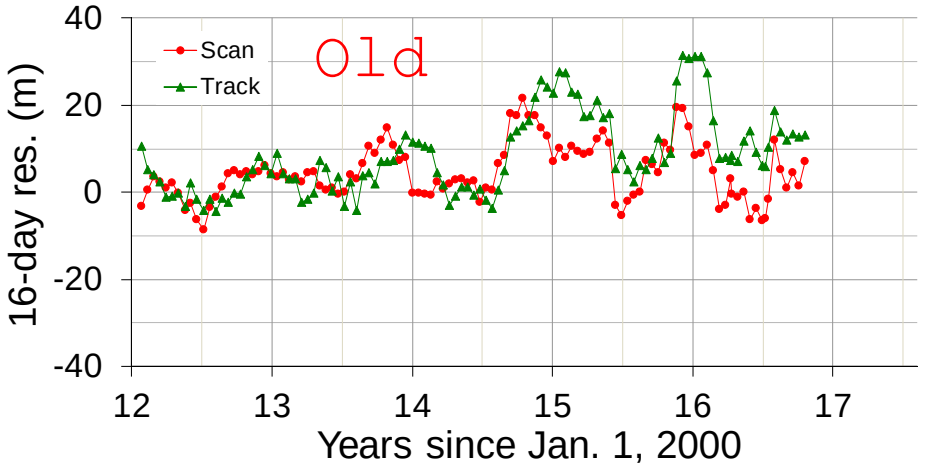
➢We will assist validating J1 DNB on-orbit geolocation

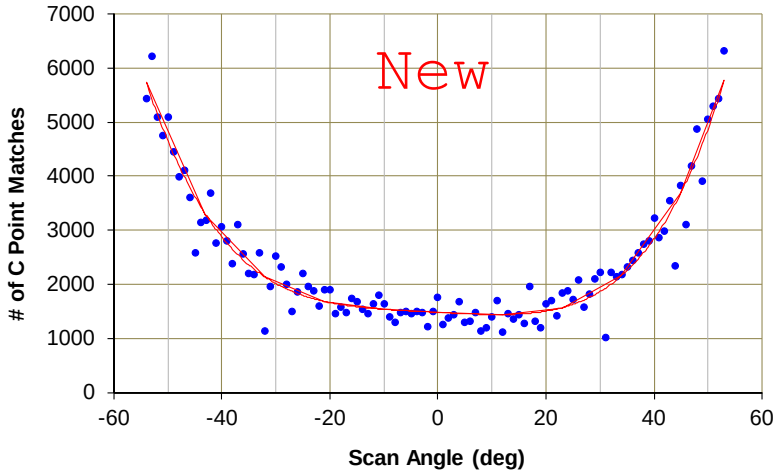
Part 2: SNPP updates for J1 VIIRS geolocation

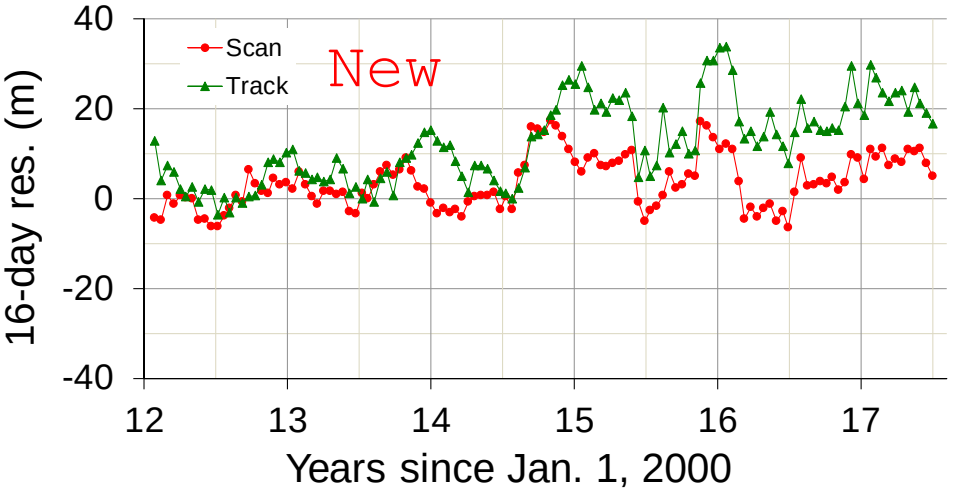
- Improvements completed for SNPP → J1
  - Ground-truthing tool, the Control Point Matching (CPM)
  - Timely delivery of spacecraft diary data
  - One-sided star tracker re-alignment - - no more
  - SNPP star tracker cooling - - reduced frequency of attitude excursions
  - Leap second insertion
- Improvements in the making for SNPP → J1
  - Position error after inclination adjust maneuvers
  - Imagery EDRs using ellipsoidal vs TC geolocation input

CPM code update



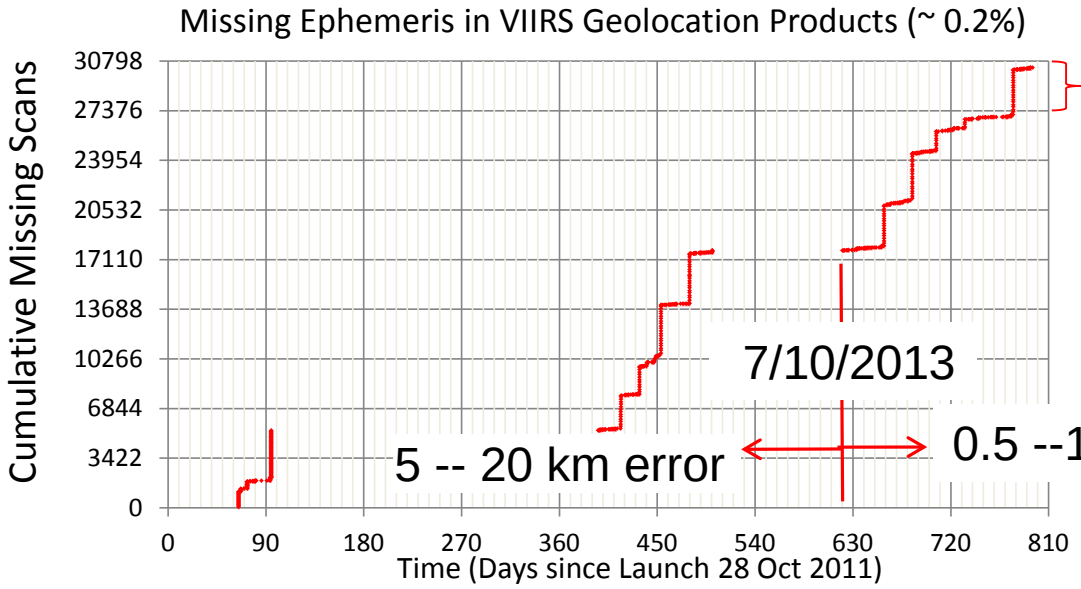




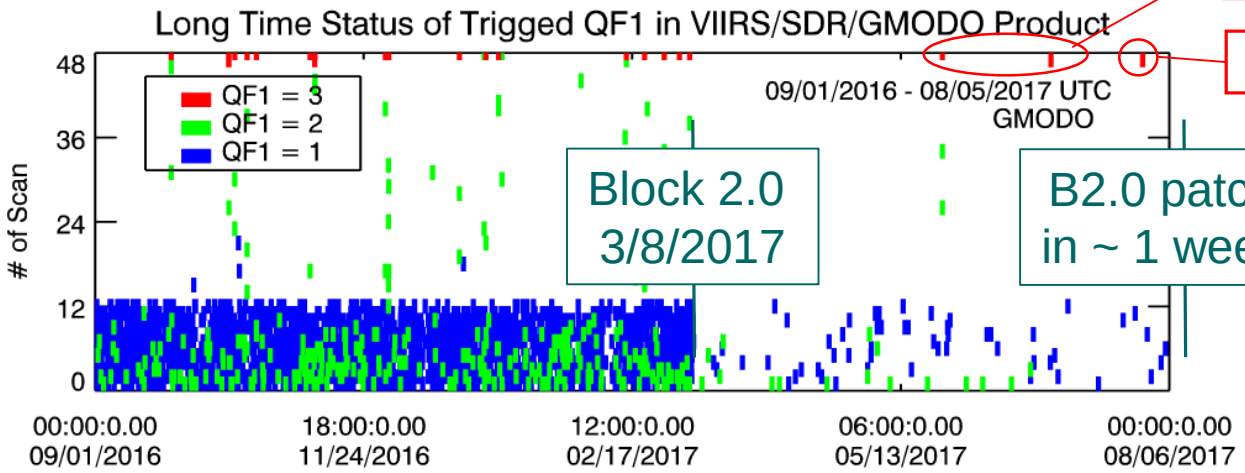


- Bugs are fixed in handling the cross-aggregation zone and cross-scan boundaries (& fixed a few other bugs)
- Measurements of biases are about the same -- drifts in the track (pitch) direction

Timely spacecraft diary delivery



One orbit diary data delivery delay
➔ TLE data use
➔ geolocation inaccuracy



Data re-transmissions

Mx3 TTO human error

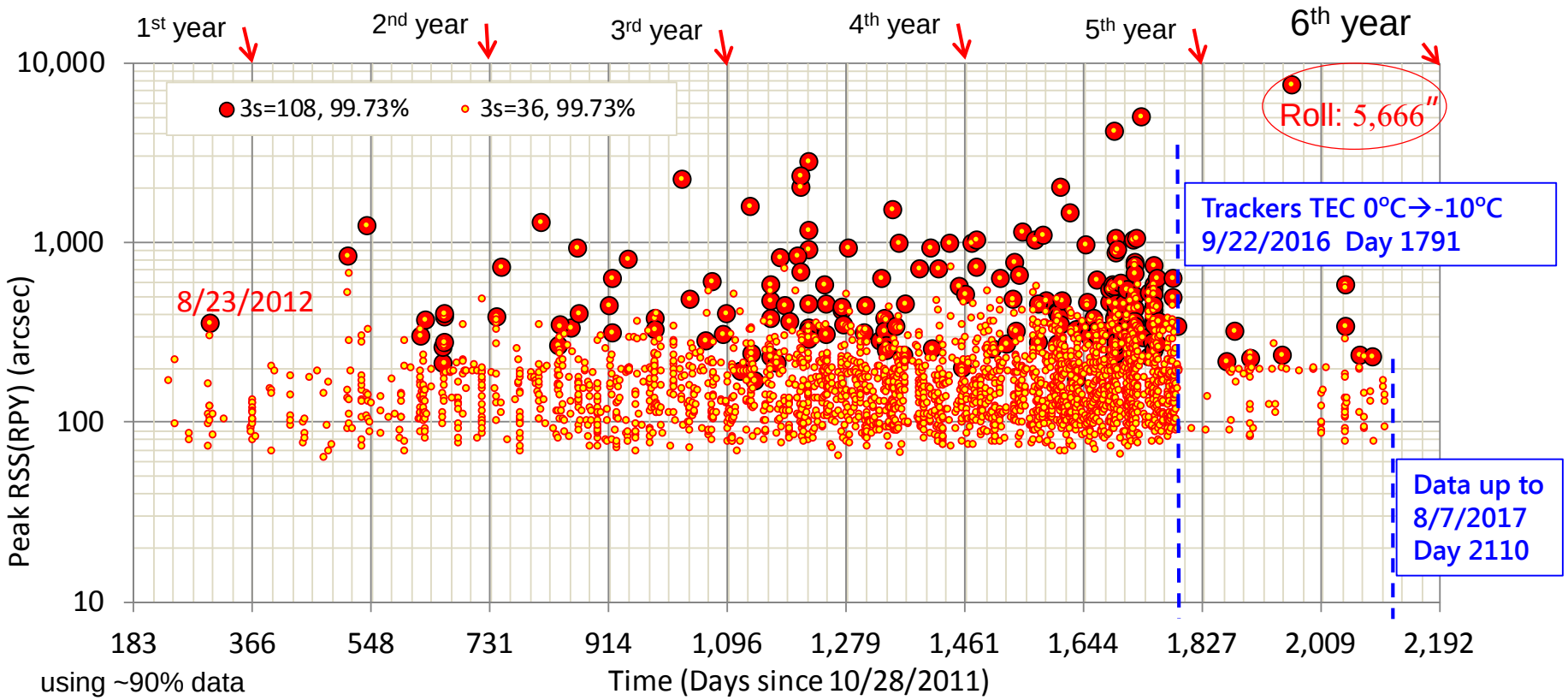
Block 2.0
3/8/2017

B2.0 patch in ~ 1 week ➔ Hope no more data delays

Credit: https://www.star.nesdis.noaa.gov/icvs/status_NPP_VIIRS.php

Improvements in SC attitude performance

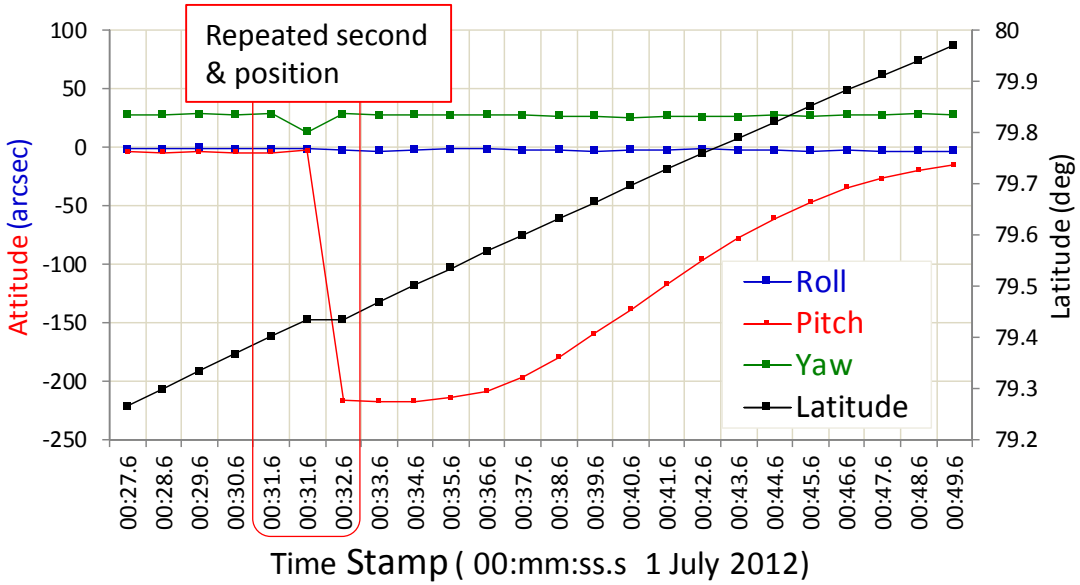
- - Spec outage and trend



- Large circles for control spec outage; Small dots hint knowledge spec outage
- Star tracker cooling improved SNPP attitude performance
- We are seeking for further improvements[3]
- We are developing SW with Kalman filter to refine the attitude for NASA SIPSs
- J1 is expected to perform better but we need to monitor/verify

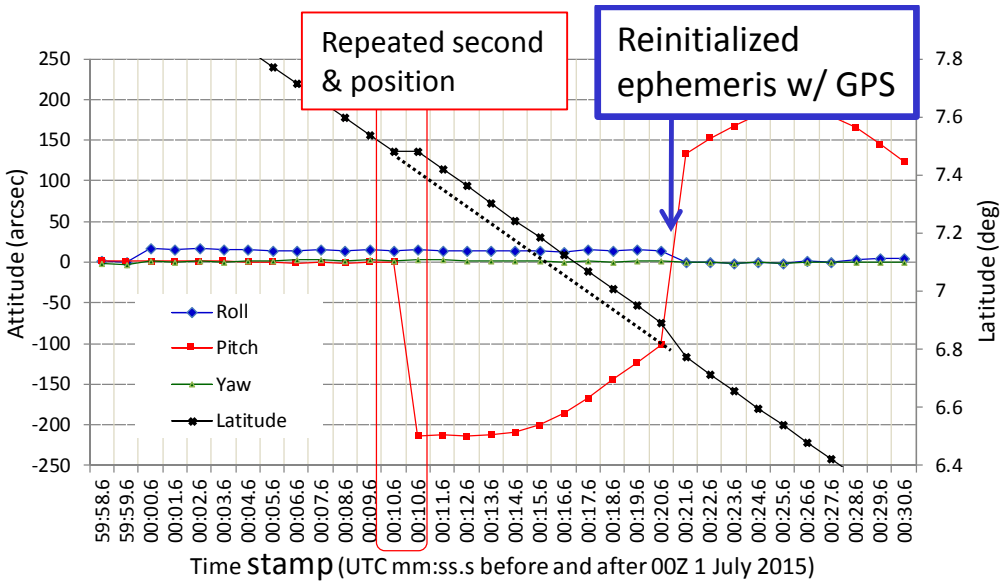
3. My eRooms > S-NPP Flight Operations and Support > FARB > All Discussion Topics--Artifacts and Minutes > DR 6348--SNPP STAR TRACKER DEGRADATIONS OVER MISSION LIFE: ATTITUDE EXCURSIONS AND LUNAR INTRUSIONS > SNPP ADCS and Geolocation Report

Impact from leap second insertion



Original

Leap second insertion at the start of **1 July 2012** impacted geolocation for ~ **3 hours**, primarily due to convergent time in shifted position of ~ 7 km.



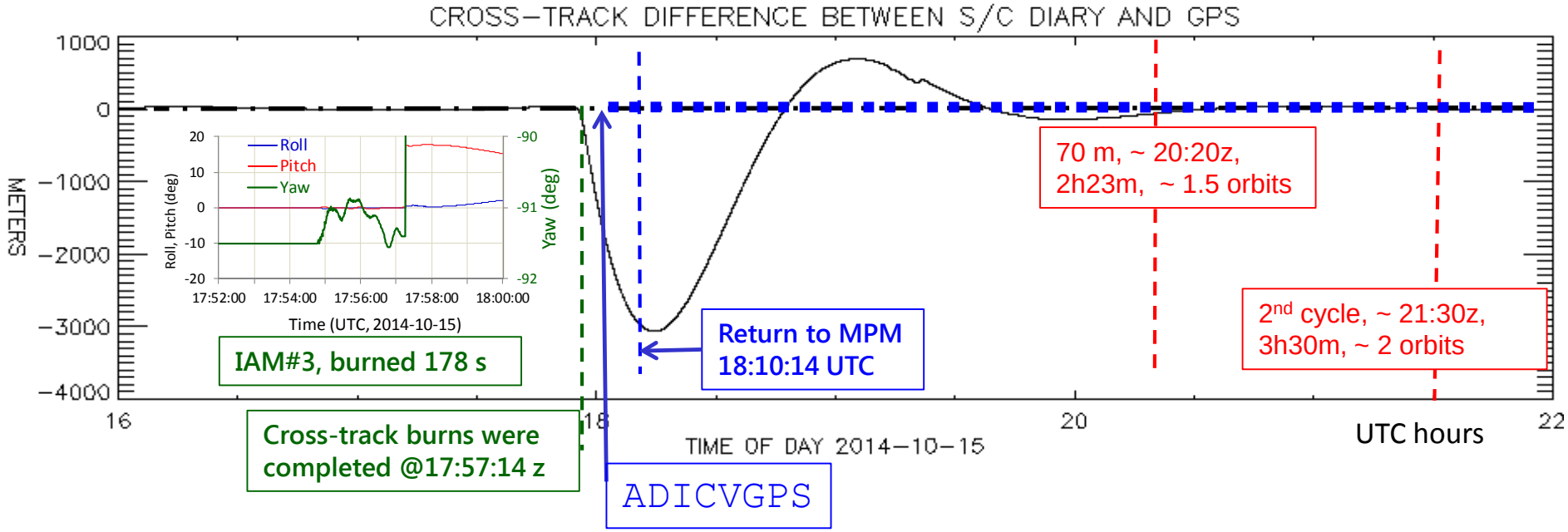
Improved

Leap second insertion at the start of **1 July 2015** and later events impacted geolocation only **1-min**, with ephemeris re-initialized to GPS (command ADICVGPS)

Part 2: SNPP updates for J1 VIIRS geolocation

- Accomplished improvements
  - Ground-truthing tool, the Control Point Matching program (CPM)
  - Timely delivery of spacecraft diary data
  - One-sided star tracker re-alignment - - no more
  - SNPP star tracker cooling - - reduced frequency of attitude excursions
  - Leap second insertion
- Improvements in the making for SNPP → J1
  - Position error after inclination adjust maneuvers
  - Imagery EDRs using ellipsoidal vs TC geolocation input

Minimize errors after IAMs

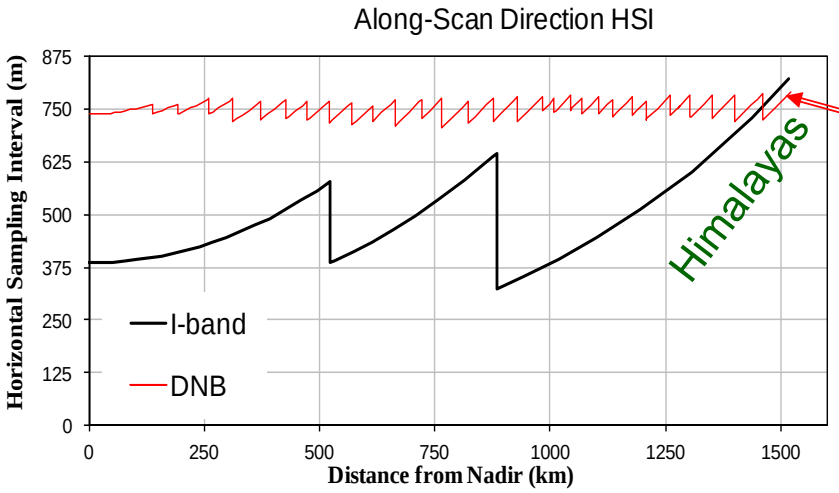


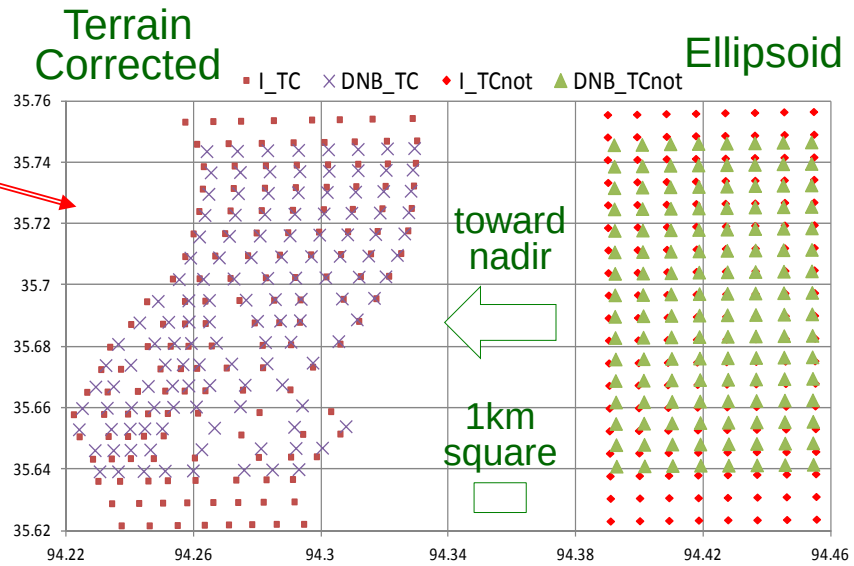
- An Inclination Adjust Maneuver (IAM) pushes the orbit sideway, making the orbit plane to incline toward earth rotation axis (once per year)
- The on-board orbit propagator does not respond to the position change quick enough, yielding position error up to **3000 m** in this case
- Orbit knowledge convergence takes about 1.5 to 2 orbits.

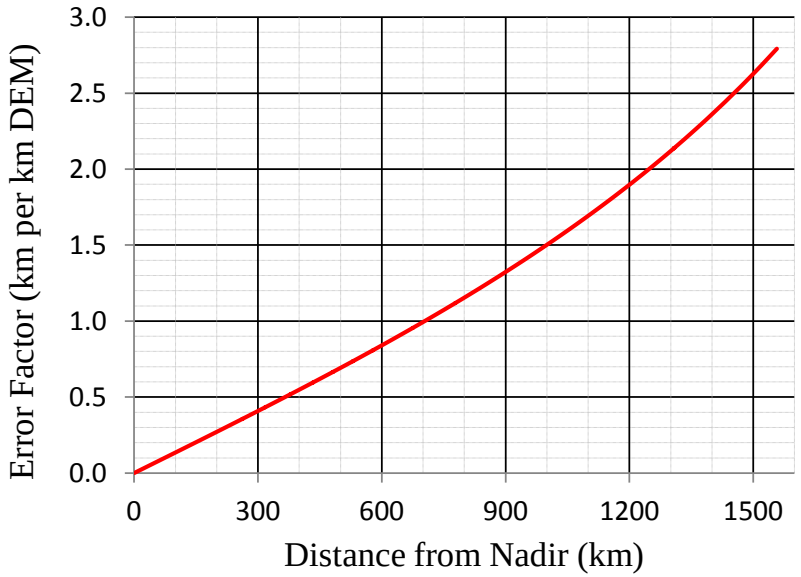
- The MOT folks “are looking to into being able to” re-initialize ephemeris with GPS with command ADICVGPS for IAM planned on 9/20/2017
- The same could be applied to DMUs/RMMs (~ 5 times per year), that have position errors ~ 150 m

Assisting Imagery EDR Team:

Terrain To be or not to be corrected?







- The error in un-corrected ellipsoid geolocation data products depends on position off-nadir and terrain height
- Maximum error factor is ~2.7 km / 1 km terrain height
- Imagery EDR is currently based on ellipsoid geolocation – mountains move from one swath to the next

Note: terrain corrected geolocation products are available for IMG, MOD and DNB

Concluding Remarks

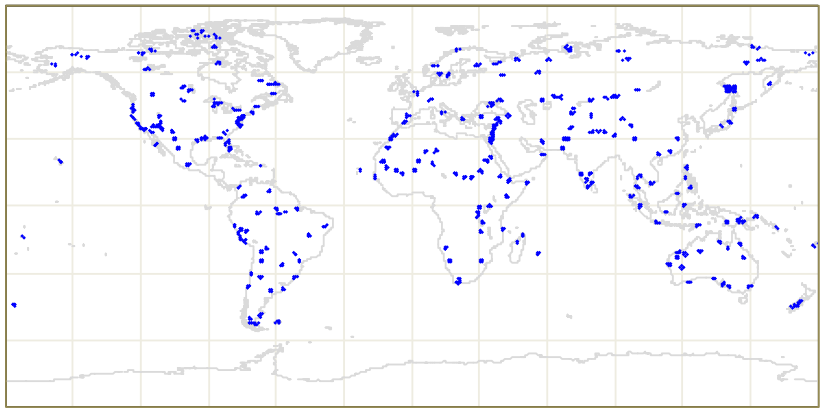
- J1 VIIRS geolocation is expected to perform better than that of SNPP VIIRS, as anomalies (issues) have been resolved, caveats (known deficiencies, challenges and concerns, and curiosities) have been looked into, and lessons learned
  - Due diligence still needs to be performed
- J1 on-orbit geolocation Cal/Val preparation is well underway

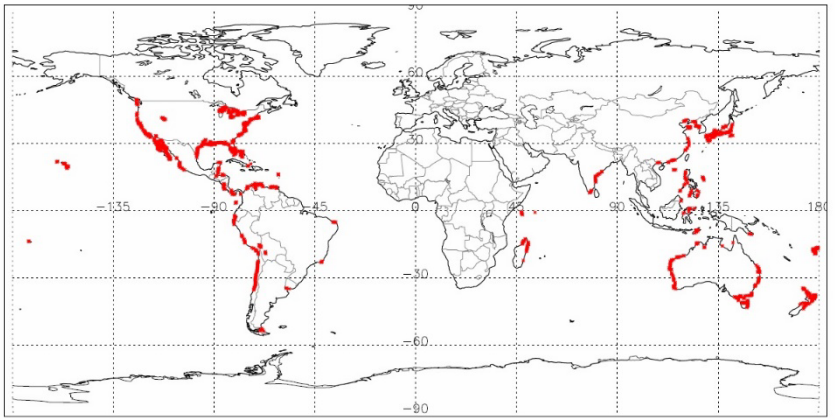
Posters

1) J2 VIIRS ground test data analysis
2) On-Orbit Measurement of the Focal Length of the SNPP VIIRS Instrument

Backup

Control point chips supplements

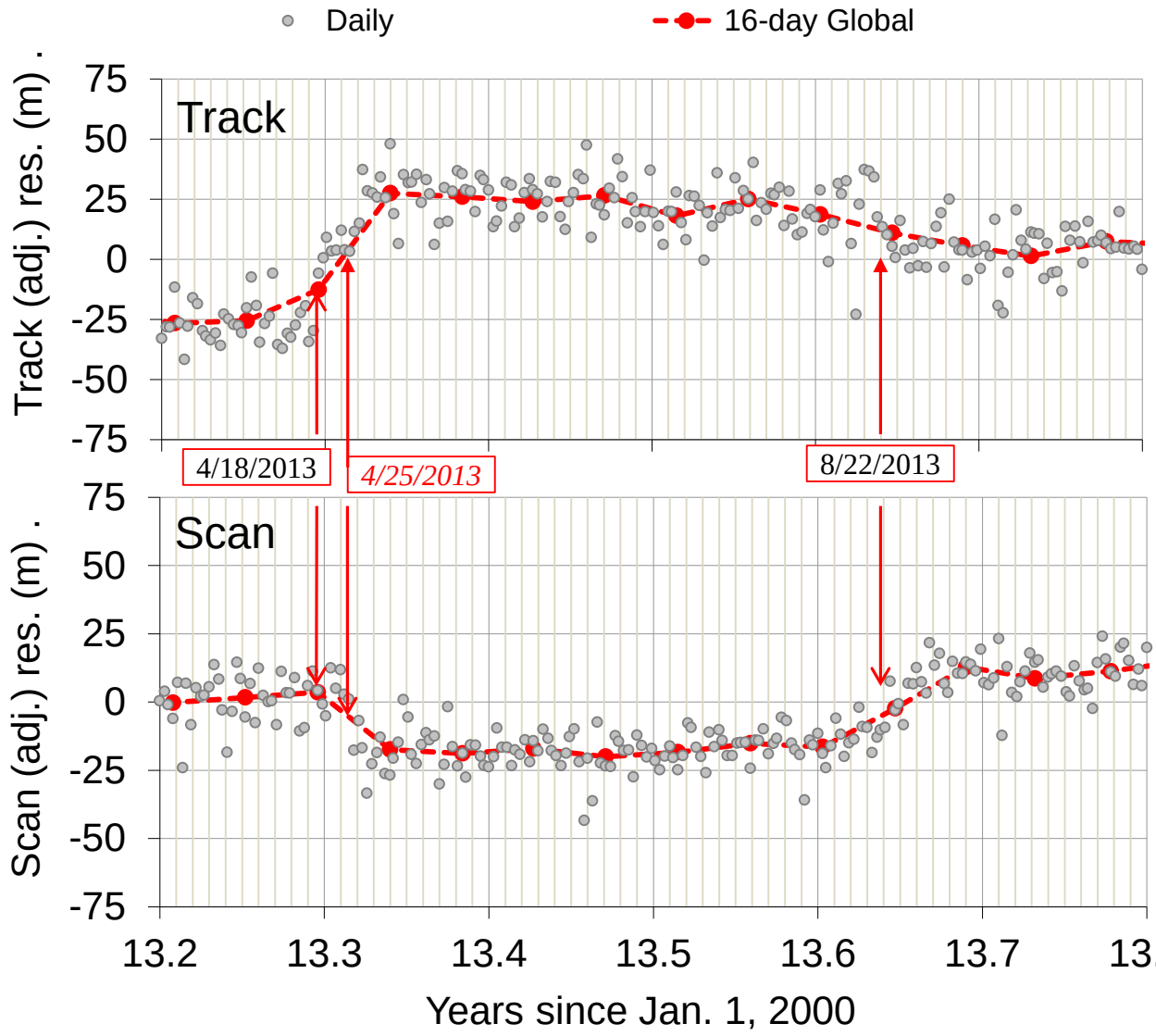




Over 1200 Ground Control Point (GCP) chips of Landsat TM red band (0.64 µm) 30 m nadir resolution, 2003 or earlier. Some chips are out-of-date and are removed from CPM for VIIRS.

To add ~4000 (planned) Ground Control Point (GCP) chips of Landsat-8 30 m nadir resolution. L8 OLI red band 4 (0.64 µm) = VIIRS I1 . Data for all other 10 bands are available. Priority is L8 TIRS band 6 (1.6 µm) = VIIRS I3. Both coastal and inland chips are being acquired.

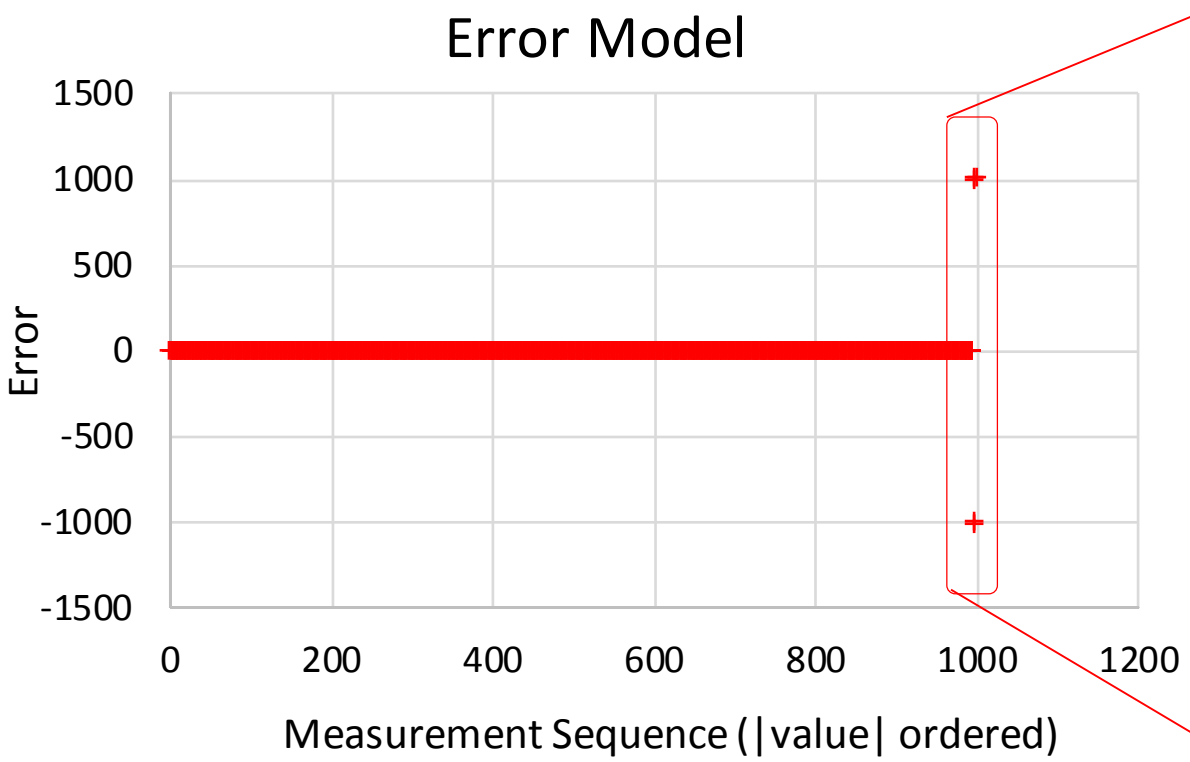
One sided star tracker re-alignment to SNPP and geolocation bias correction



- 4/18/2013:
  Geo LUTs fine tuned
- 4/25/2013:
  Star tracker re-alignment
- 8/22/2013
  Error ~ 25 m found and corrected

One-sided re-alignment is NOT expected to happen again for SNPP and J1

Improvements & progresses by addressing anomalies, caveats & curiosities



Sequence	Error
1	0
… …	… …
995	0
996	1001
997	-1002
998	1003
999	-1004
1000	1005
mean	1.003
stdev	70.951
RMSE	70.958

- Rare cases of large errors may not show up well in the mean value
- They do affect “spread” (standard deviation) and uncertainty (RMSE = Root Mean Square Error)
- Specification in “3σ” may be violated when we interpret it as 99.73% of occurrences or detectible measurements