Suomi NPP CrIS On-orbit Geometric Calibration Performance

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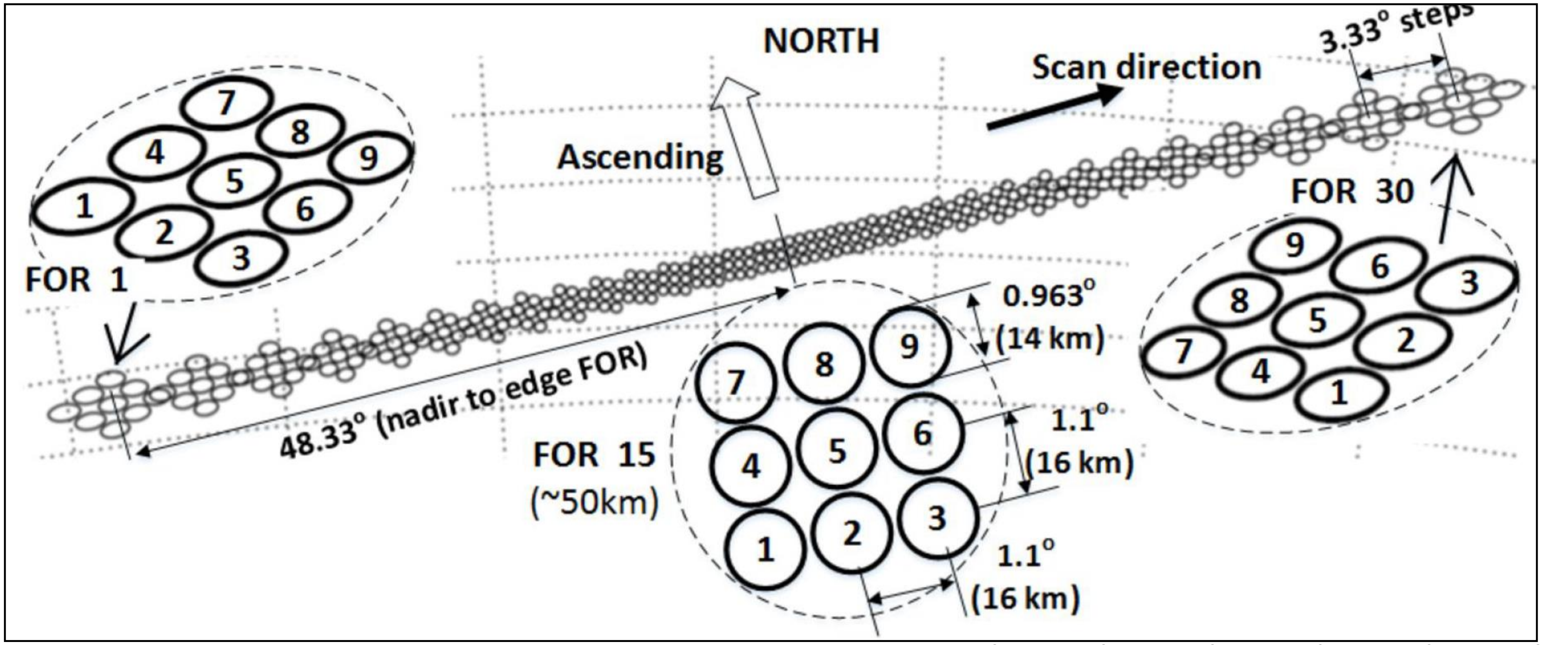
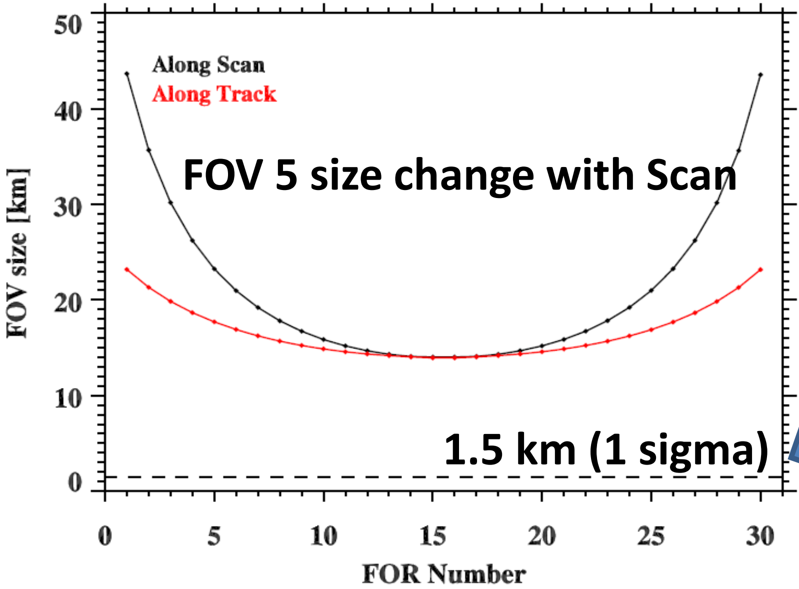
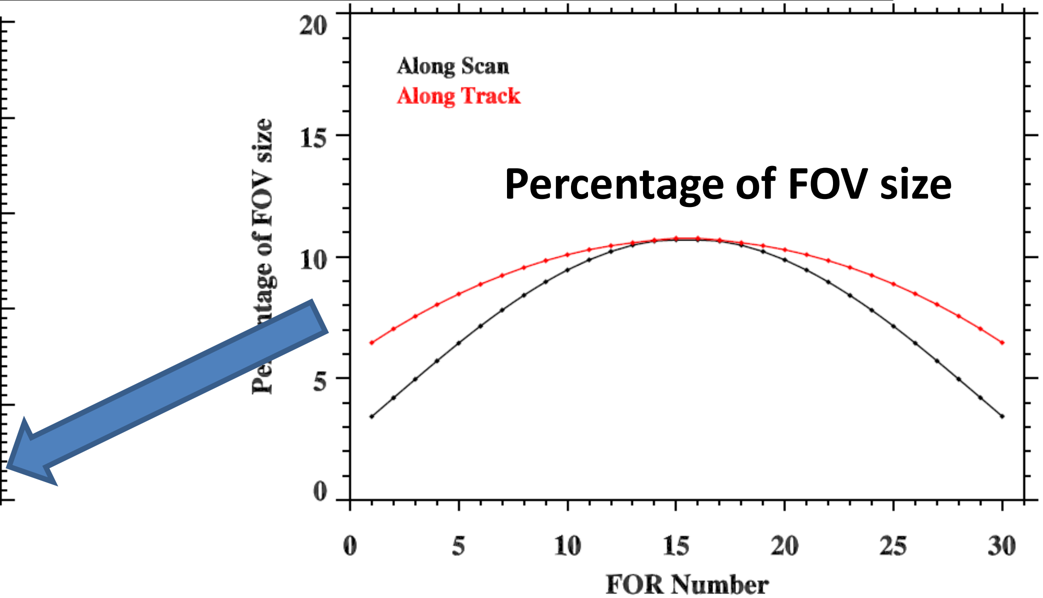
Outlines

1. Introduction and objectives
   - Specification, Algorithms, and Challenges
2. Method
   - Using VIIRS Geolocation dataset
3. Geolocation performance
   - At Nadir
   - Along with Scan Angels
   - Possible angle adjustment
4. Band-to-band co-registration
5. Geolocation changes for EP V36
6. Summary and future work

CrIS Scan Patterns and Specification

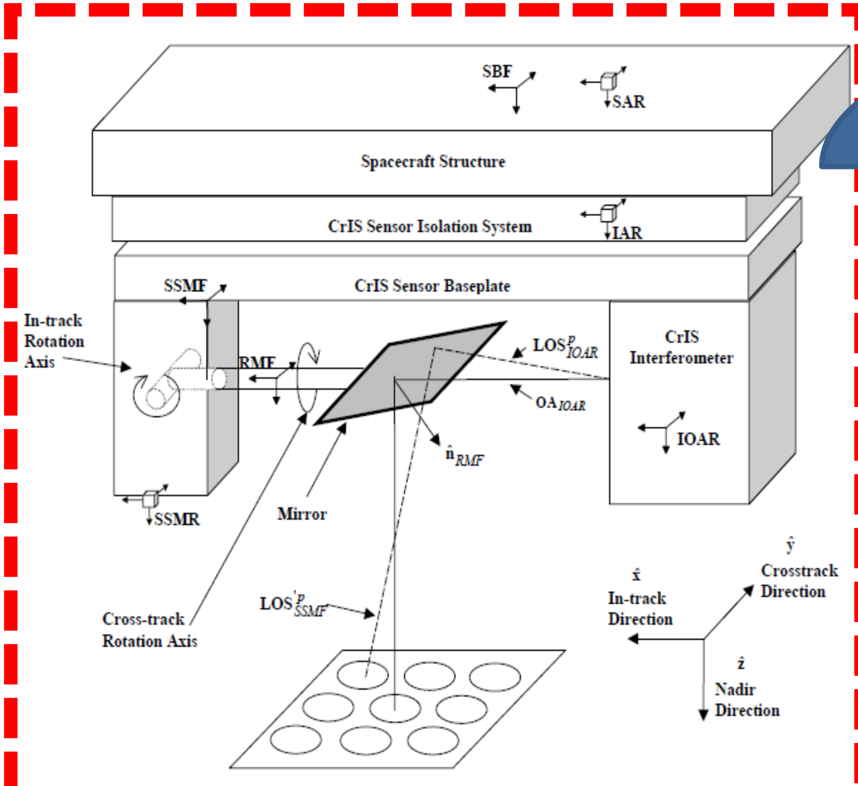






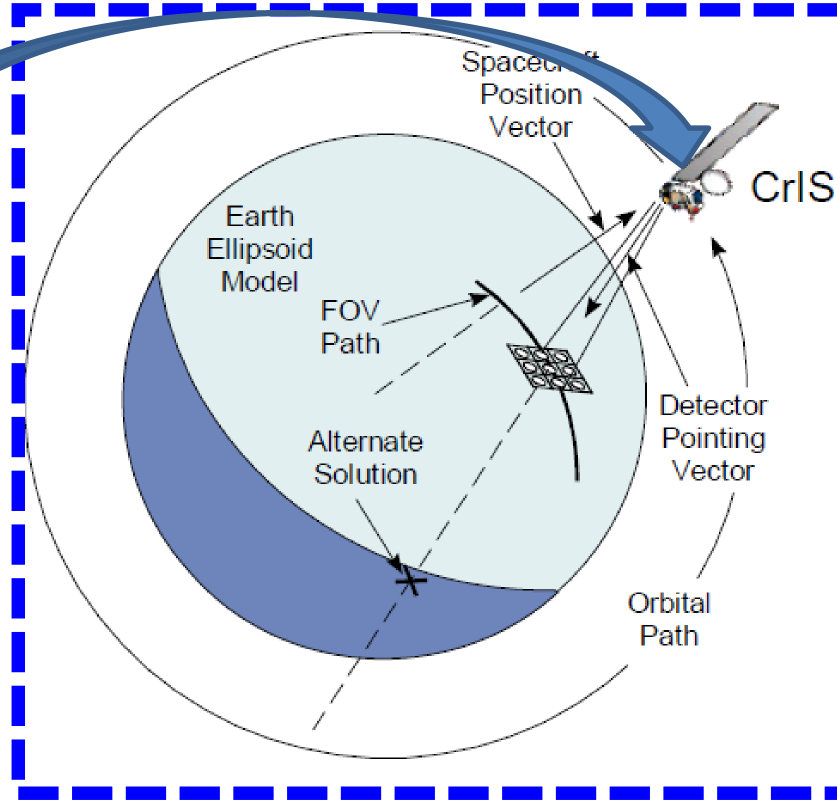
CrIS Geometric Calibration Algorithm

Sensor Level Algorithms



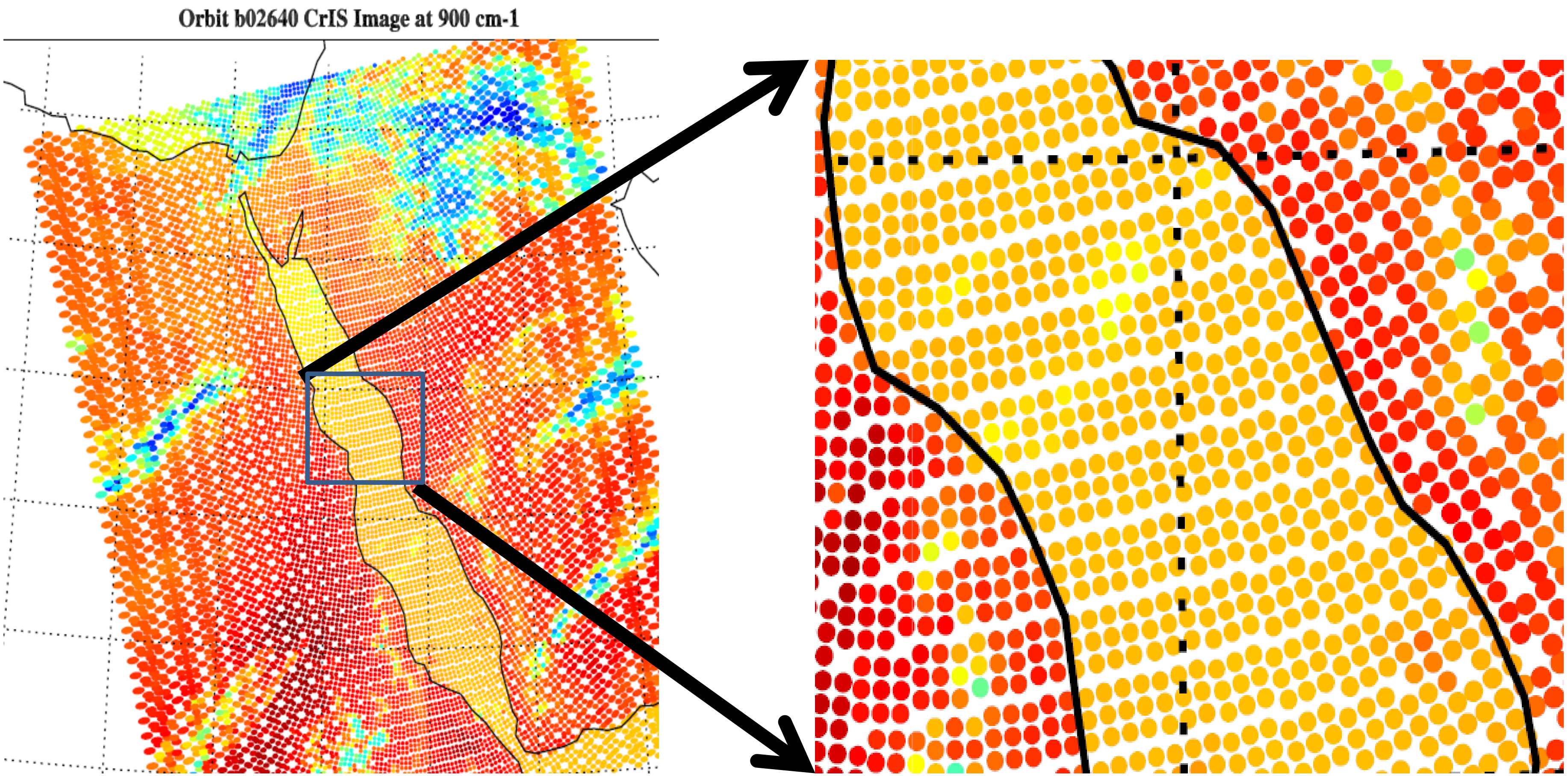
Compute the LOS relative to S/C

Spacecraft Level Algorithms



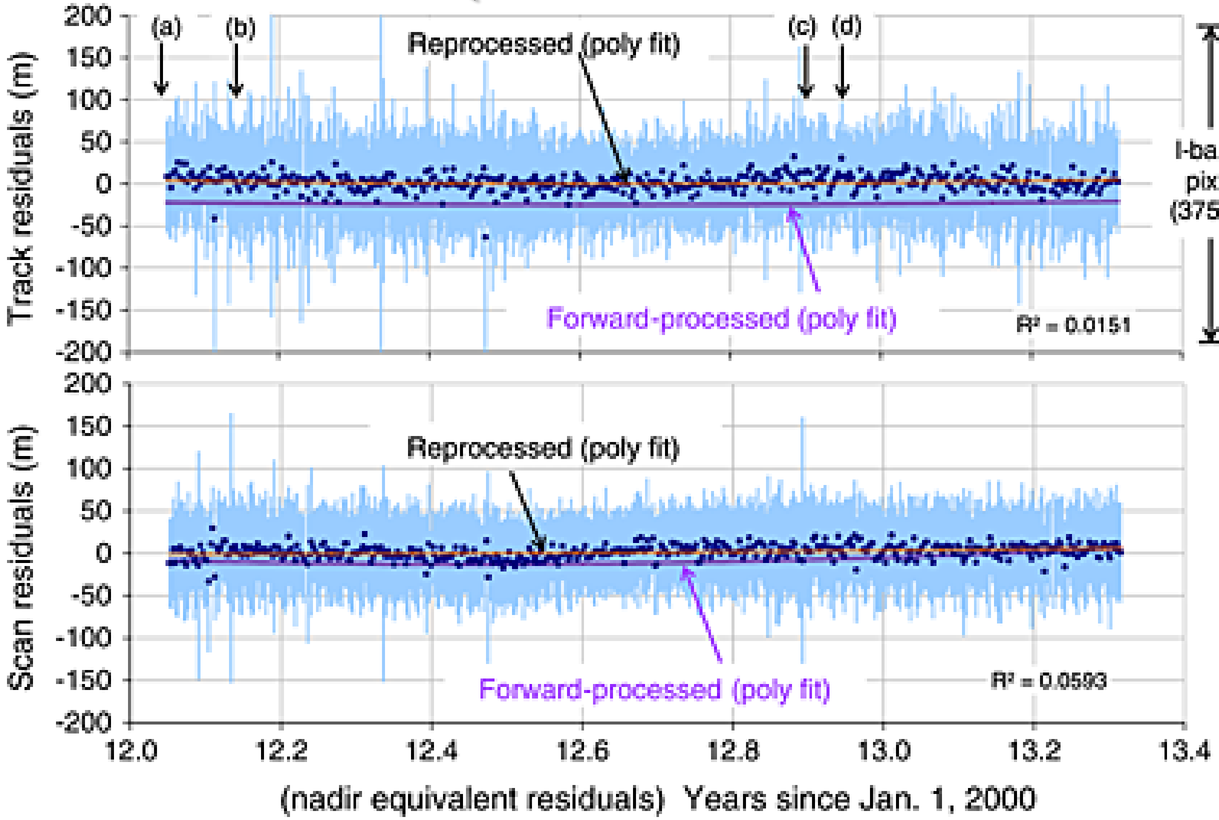
Resolve LOS intersection with Earth Ellipsoid

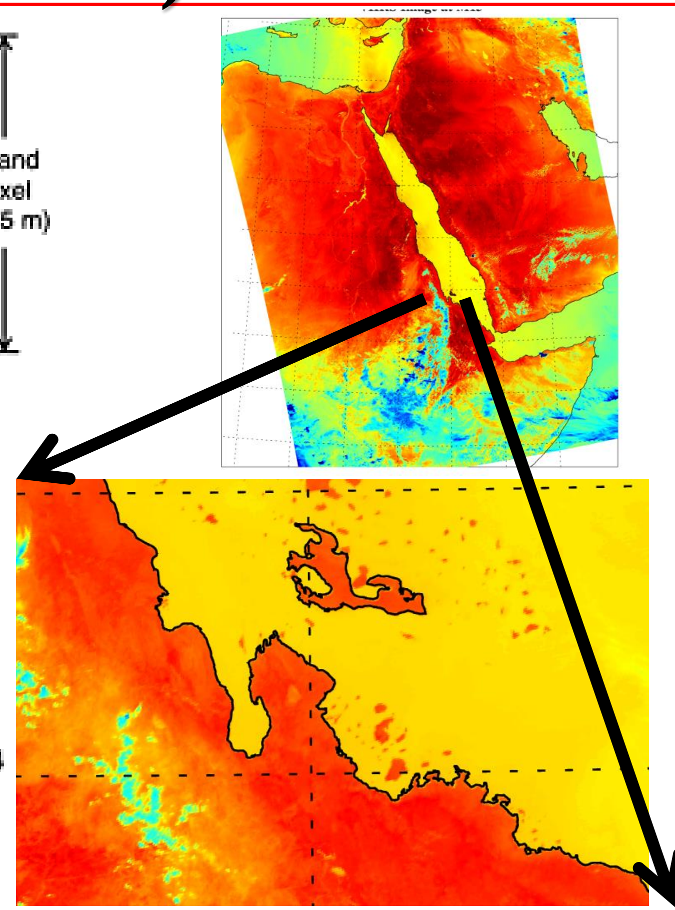
Challenges for On-orbit Assessment



Unlike an imager, it is very hard to assess geolocation sub-pixel accuracy for CrIS using the land feature method because of 1) relatively large footprint size (above 14 km); 2) the gap between footprints; and 3) Uneven spatial distribution of CrIS Footprints

Reference: Using VIIRS Geolocation (I5 band: 375m resolution)





from Wolf et al. 2013

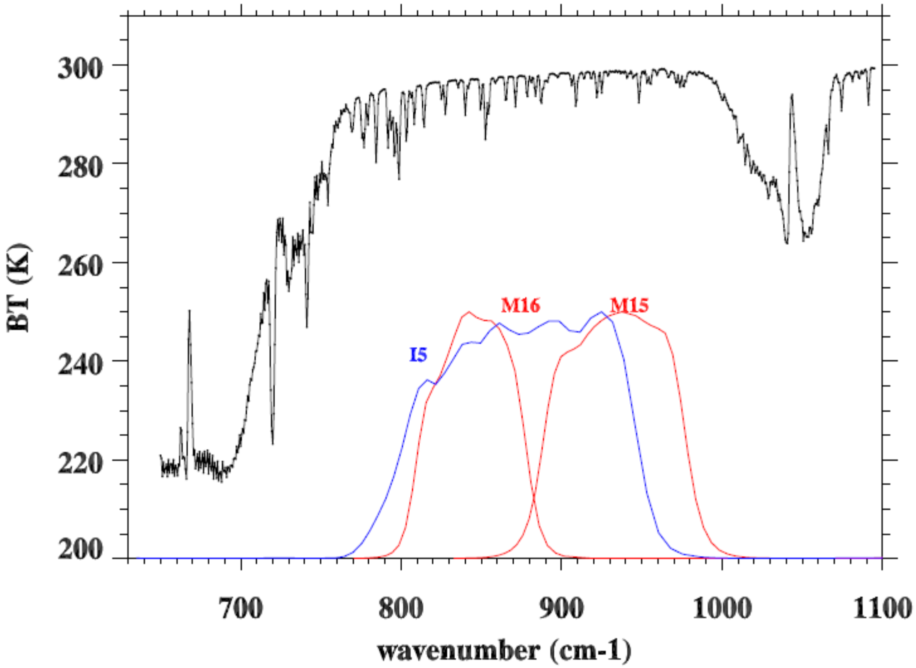
Table 2. VIIRS Geolocation Accuracy

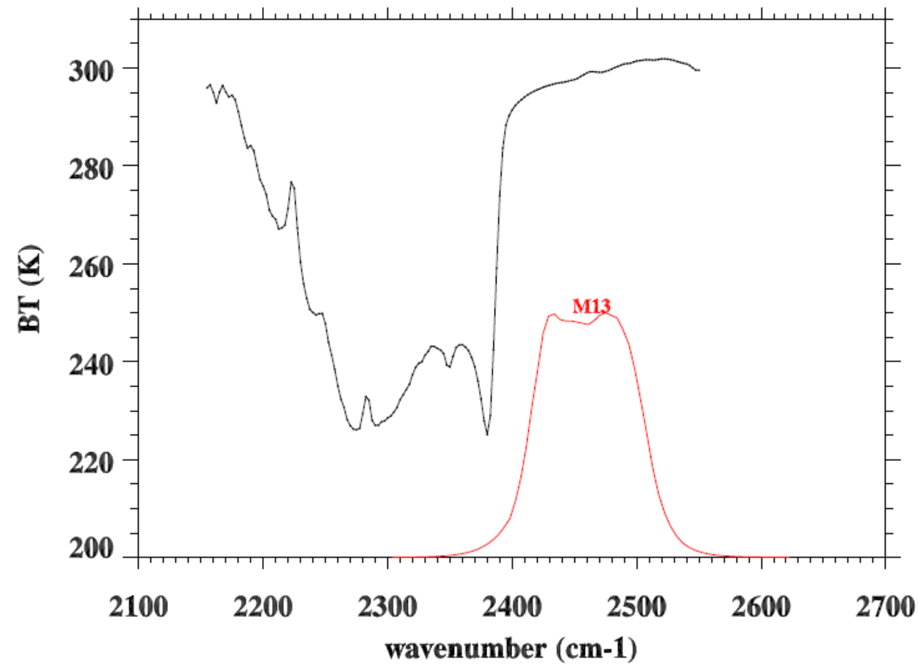
Residuals	First Update 23 February 2012	Second Update 18 April 2013
Track mean	**−24 m, −7%**	**2 m, 1%**
Scan mean	**−8 m, −2%**	**2 m, 1%**
Track RMSE	**75 m, 20%**	**70 m, 19%**
Scan RMSE	**62 m, 17%**	**60 m, 16%**

Spectral Integration: from CrIS to VIIRS

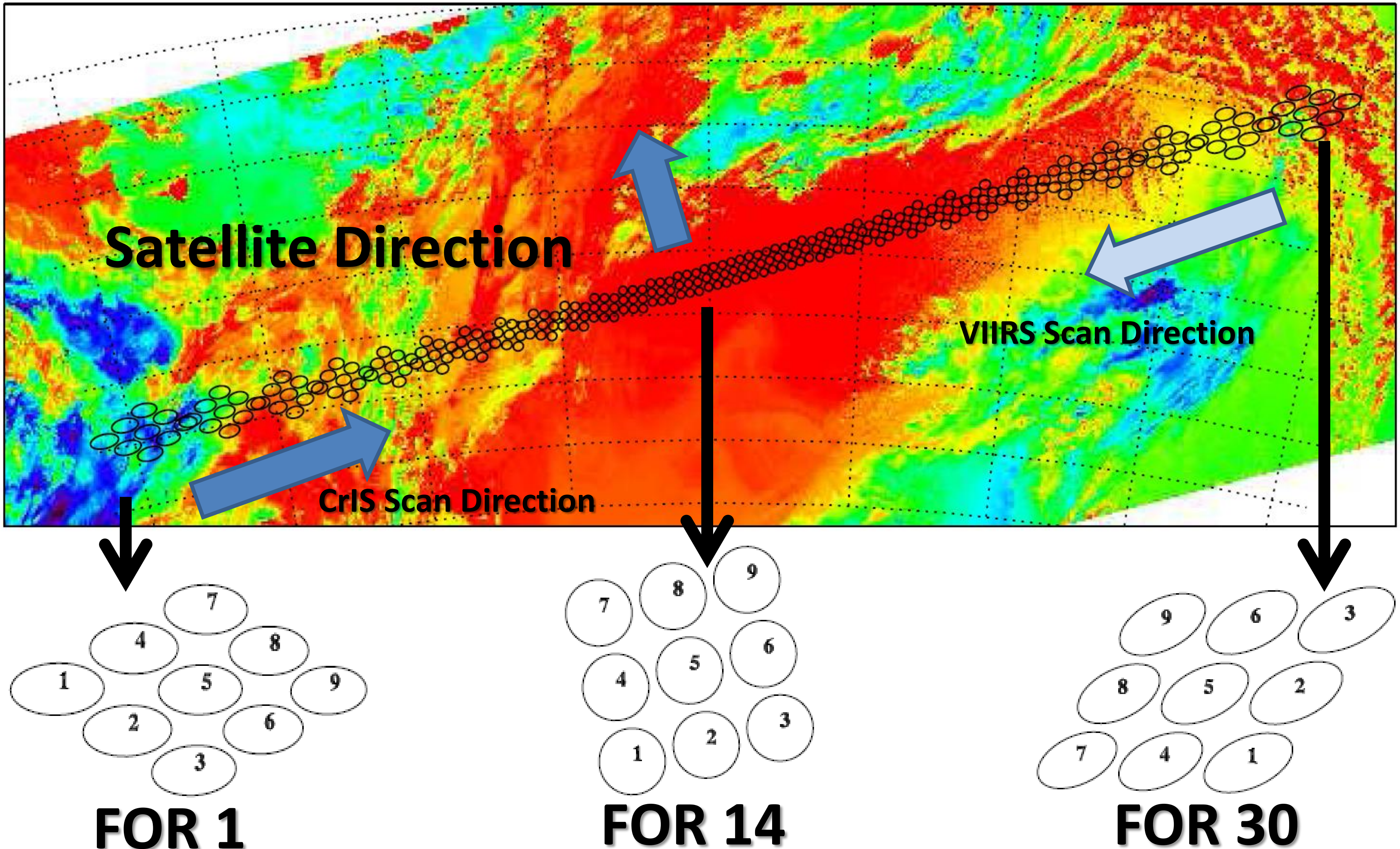
CrIS spectrum is convolved with VIIRS SRFs for I5 band (350m spatial resolution)

$$L_i = \frac{\int_{\nu_1}^{\nu_2} R(\nu) S_i(\nu) d\nu}{\int_{\nu_1}^{\nu_2} S_i(\nu) d\nu}$$

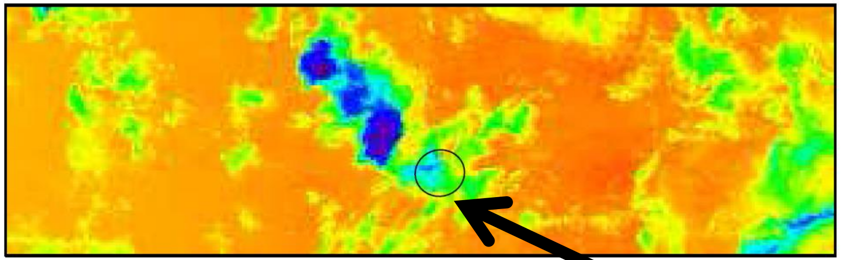




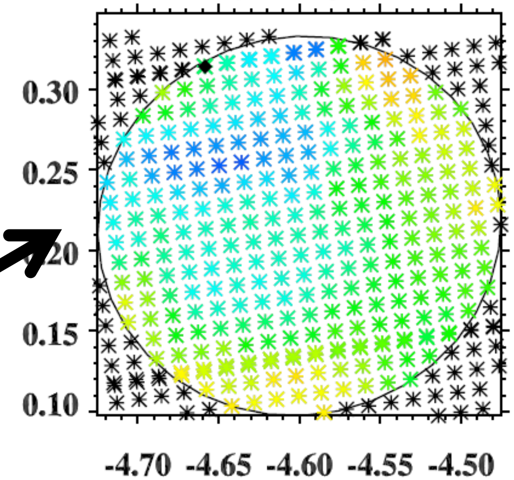
Compute CrIS FOV Footprint



Collocating VIIRS with CrIS FOV

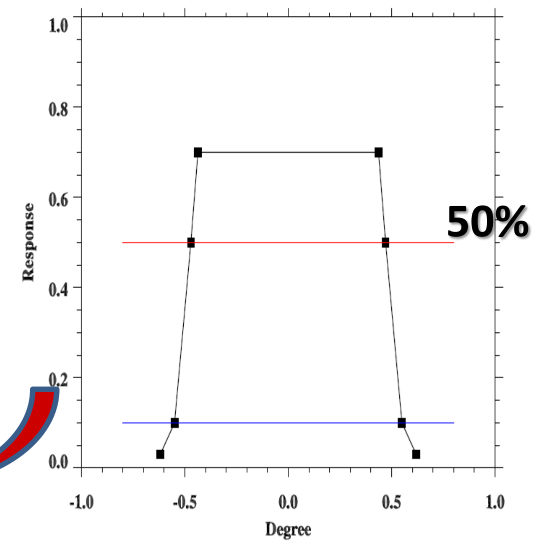


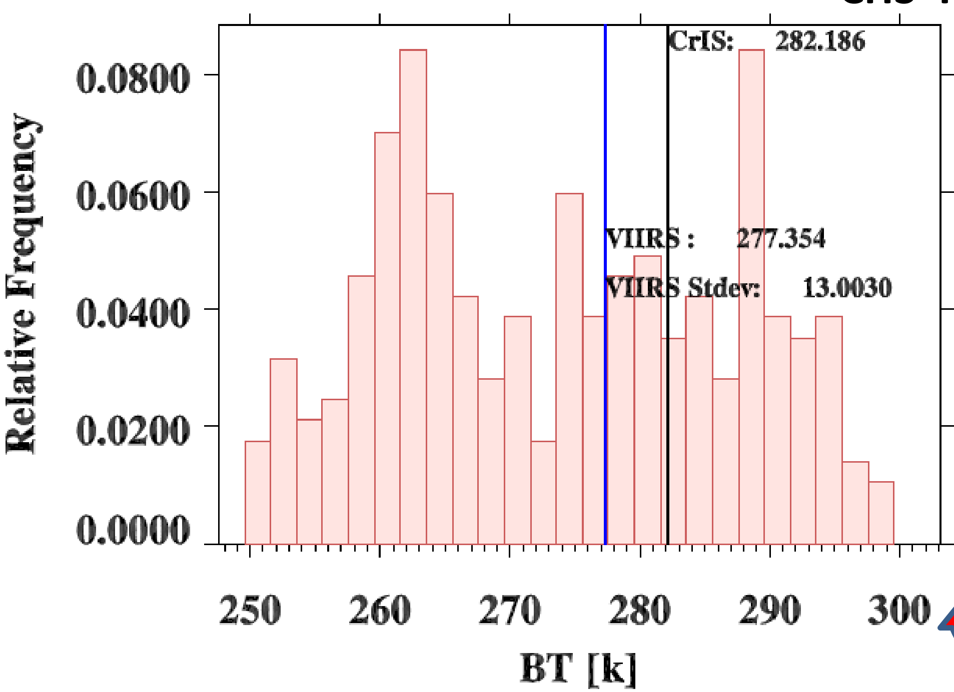
VIIRS Pixels



CrIS FOV footprint

CrIS FOV Spatial Response

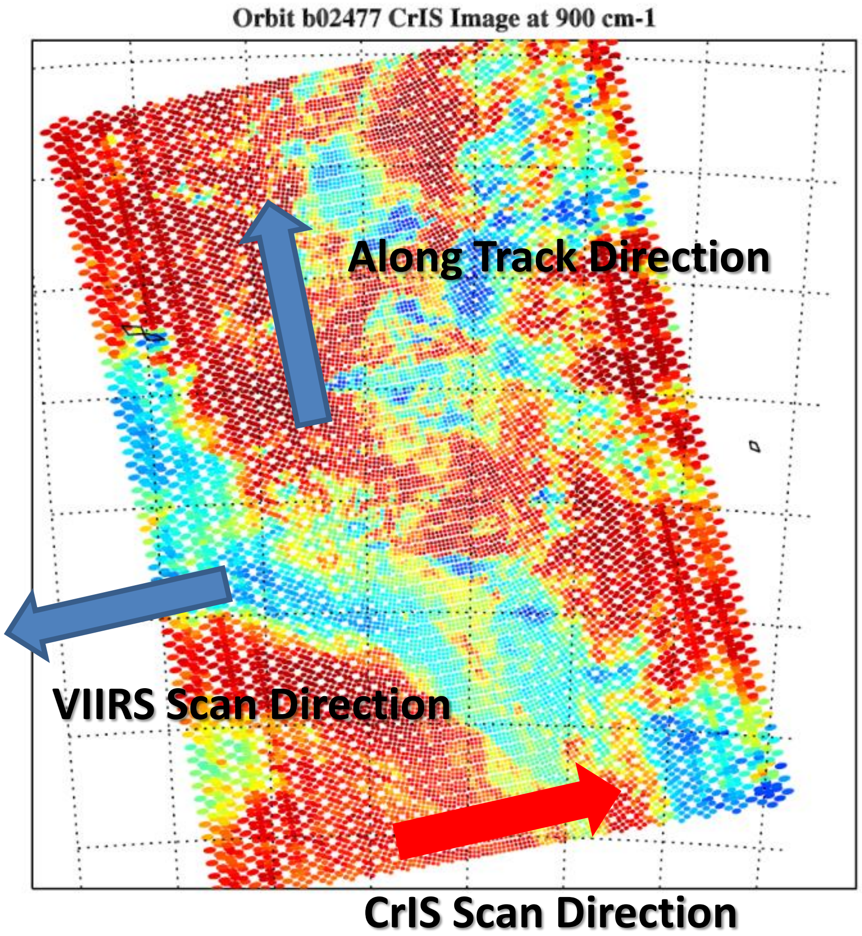




Histogram of VIIRS M16 in CrIS FOV

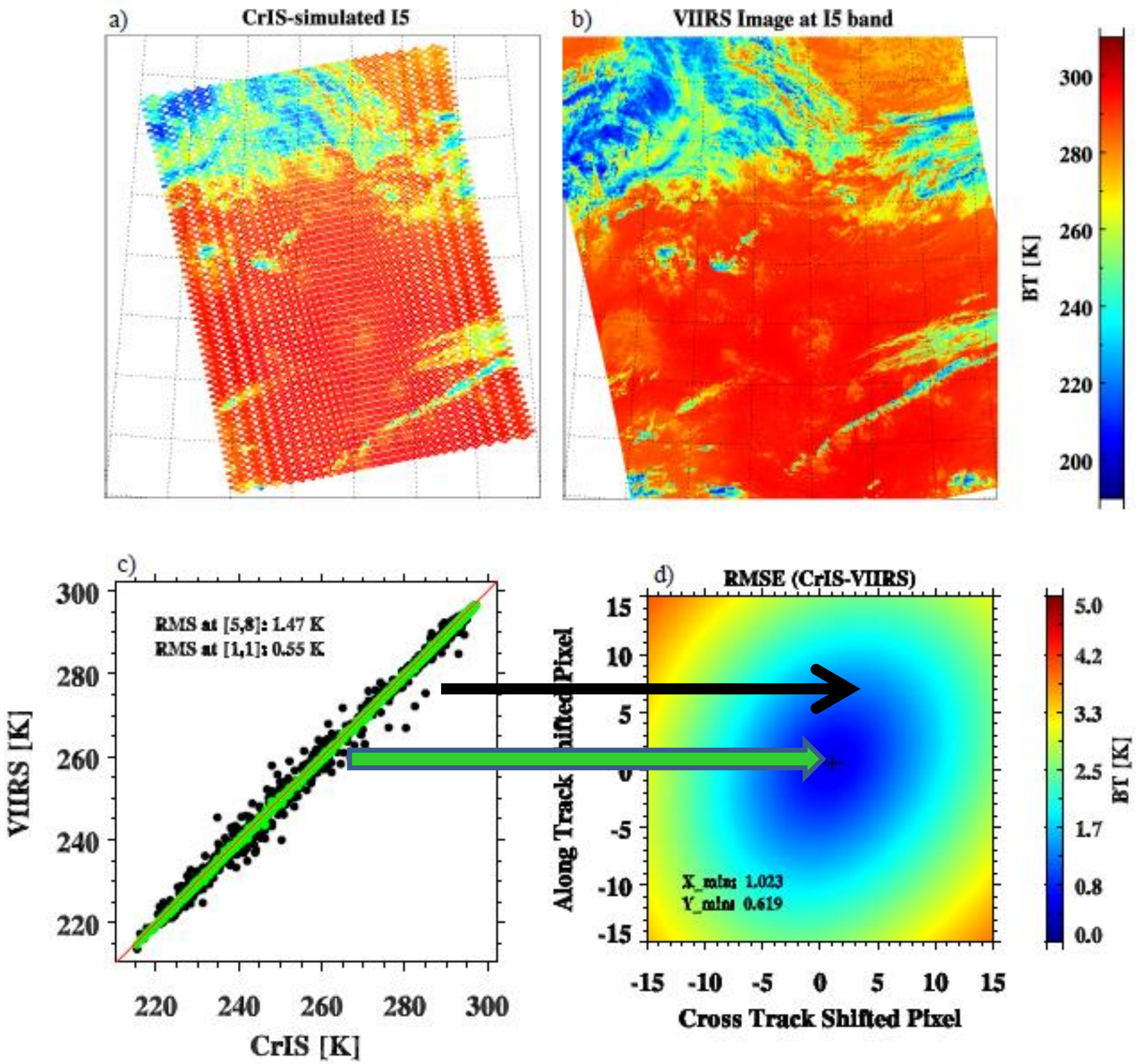
Quantitative Assessment

- Choose un-uniform (better for cloud scene) CrIS granules over tropical region (large dynamic range)
- Collocate VIIRS with CrIS **nadir** FOVs (FOR 13-16) and then compute spatially averaged radiances
- Convert CrIS spectra into VIIRS band radiances using VIIRS spectral response functions (SRFs)
- Define the cost function as ***Root Mean Square Errors (RMSE)*** of CrIS-VIIRS BT difference
- Shift VIIRS image toward **along-** and **cross-**track direction to find the minimum of the cost function, which represent best collocation between VIIRS and CrIS



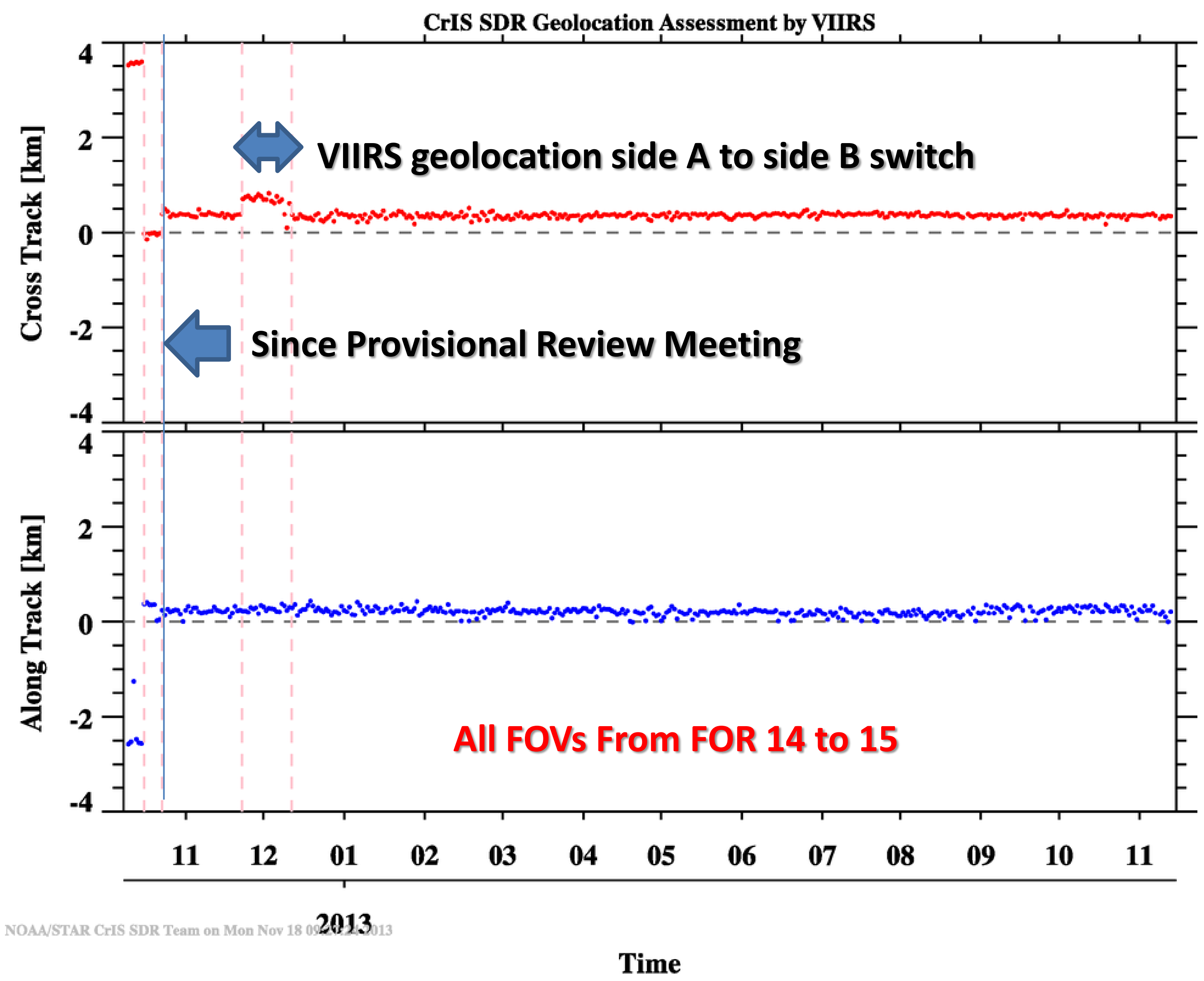
Orbit 02477 on April 20 2102

An Example

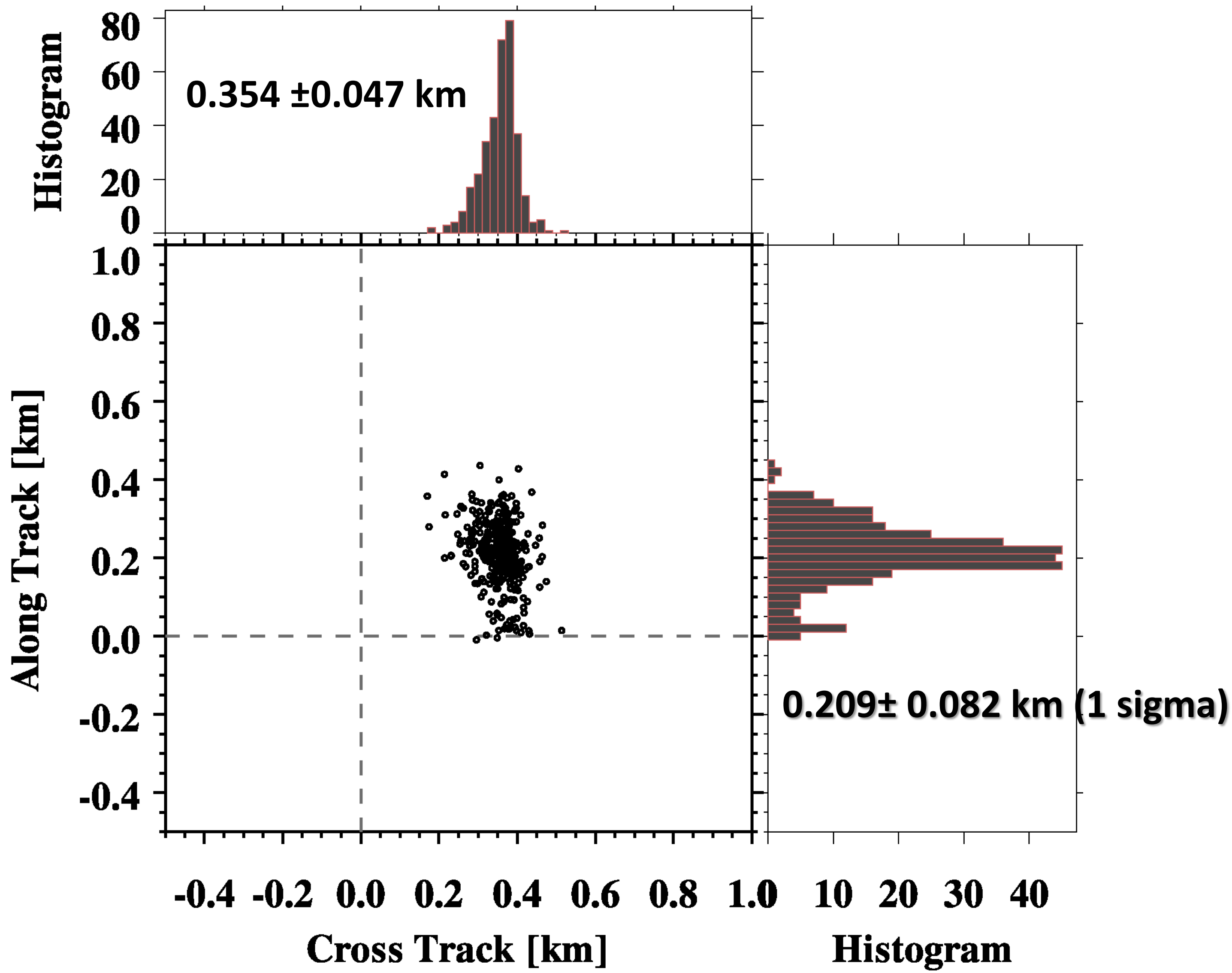


a)
CrIS-simulated I5
b)
VIIRS Image at I5 band
BT [K]
300
280
260
240
220
200
c)
RMS at [5,8]: 1.47 K
RMS at [1,1]: 0.55 K
VIIRS [K]
CrIS [K]
220
240
260
280
300
d)
RMSE (CrIS-VIIRS)
X_min: 1.023
Y_min: 0.619
Along Track Shifted Pixel
Cross Track Shifted Pixel
-15
-10
-5
0
5
10
15
BT [K]
5.0
4.2
3.3
2.5
1.7
0.8
0.0

Time Series of Assessment Results

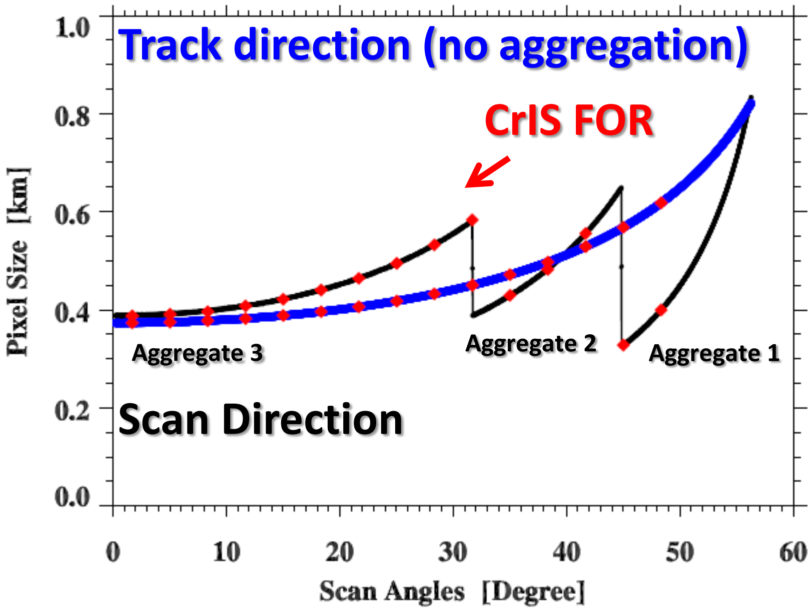


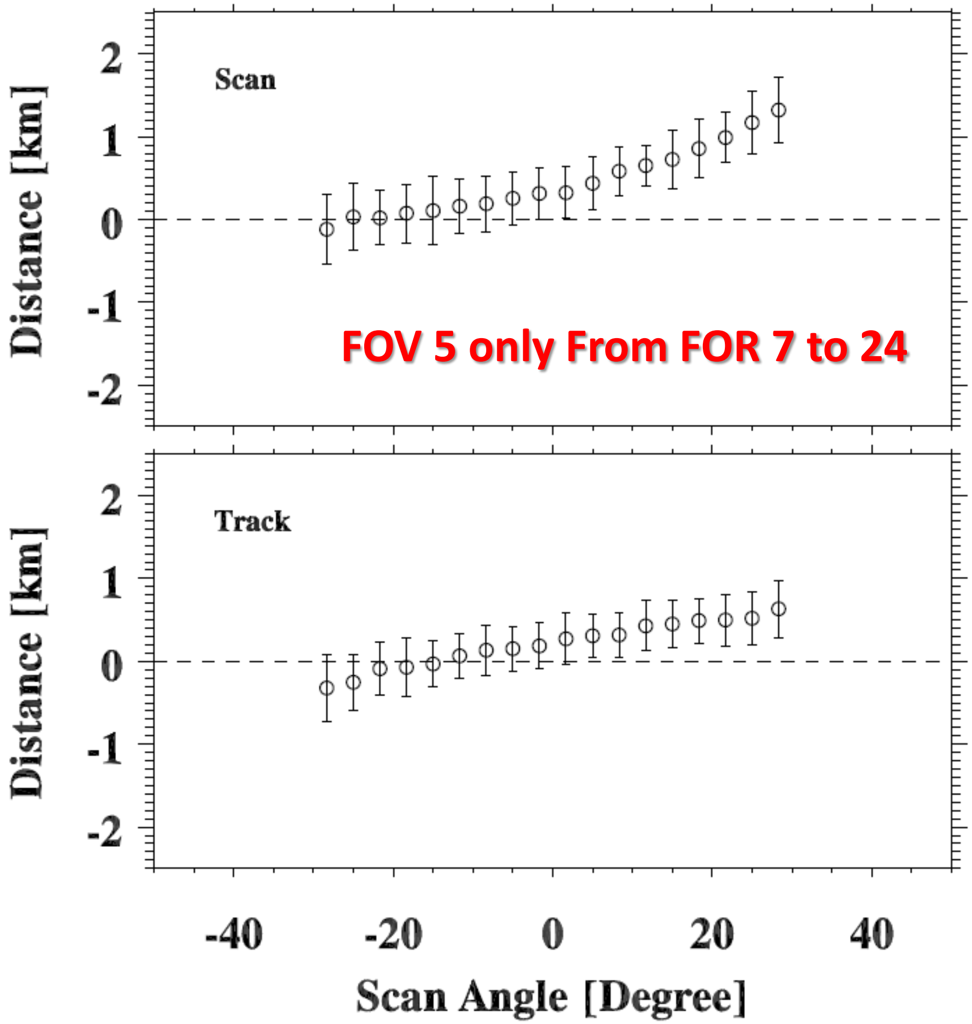
Statistical Results



Off-Nadir Assessment (within 30 degree scan angles)

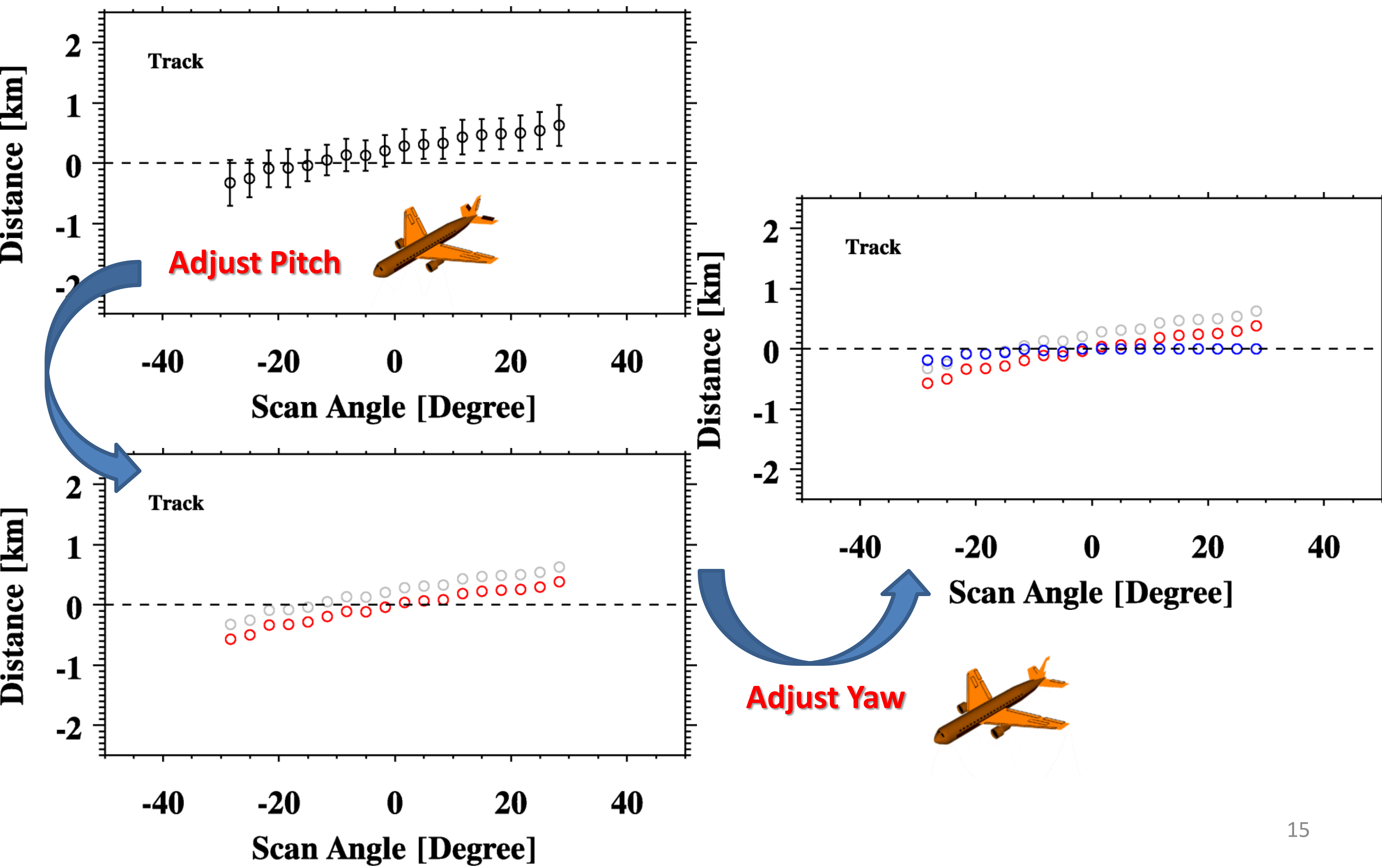
VIIRS pixel size varying with Scan angle





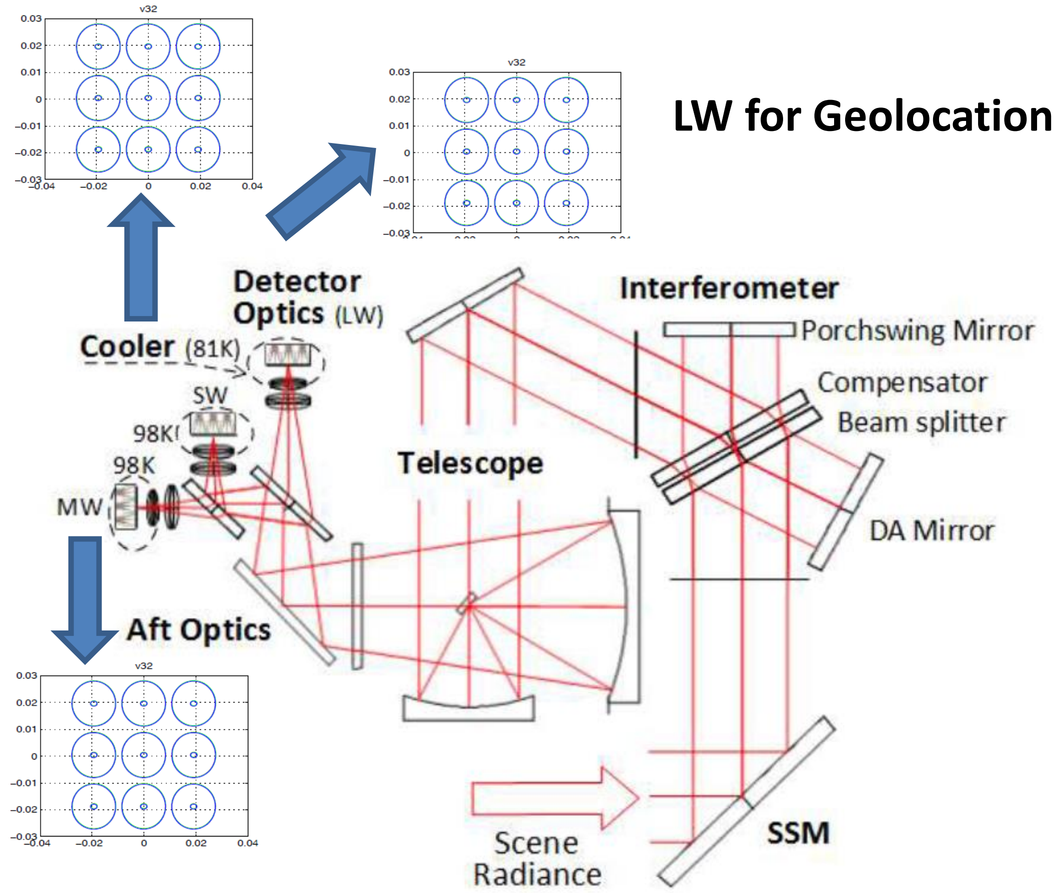
In VIIRS data, in order to minimize data rate, some of this redundant data is not transmitted and thus referred to as "bowtie deletion" when scan angle is larger than 32°.

Possible Angle Adjustment Under Discussion



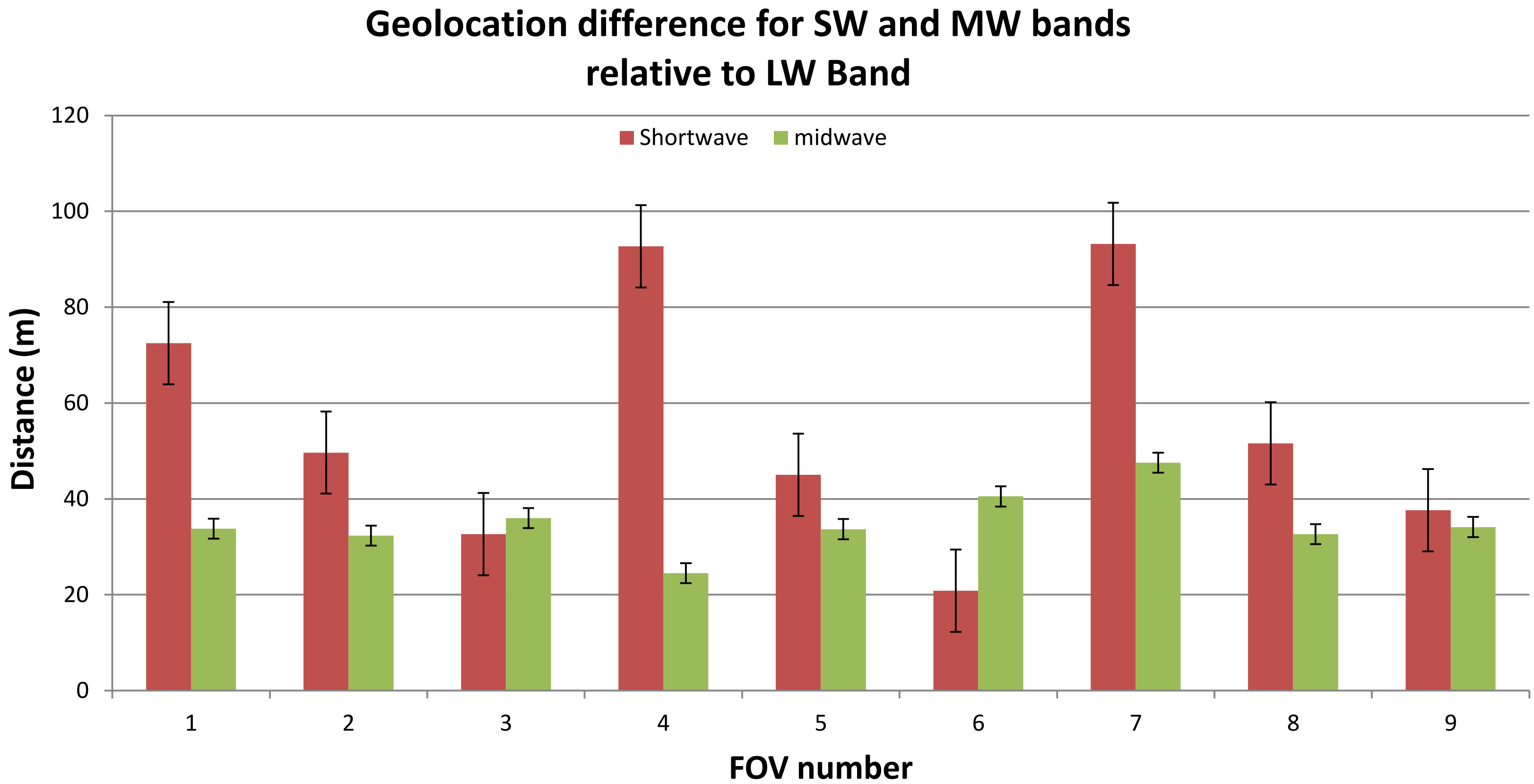
Band-to-Band Co-Registration (1)

- Three different detector arrays are used for three bands.
- Only LW detector angles are used for geolocation calculations
- LW, MW, and SW band detector angels are adjusted for FOV-to-FOV spectral calibration.
- Band-to-band co-registration for CrIS is 1.4% of FOV footprint size, which is 196 m for nadir FOV (14.0km)



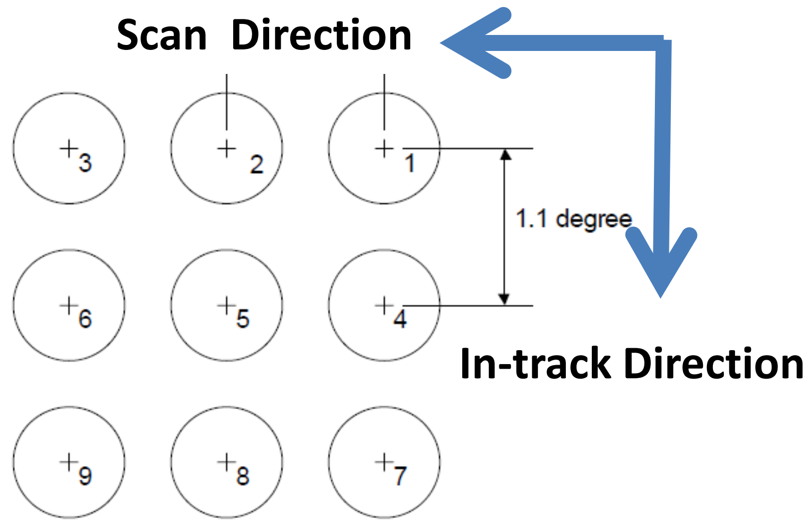
Do the three CrIS bands "see" the Earth at the same location?

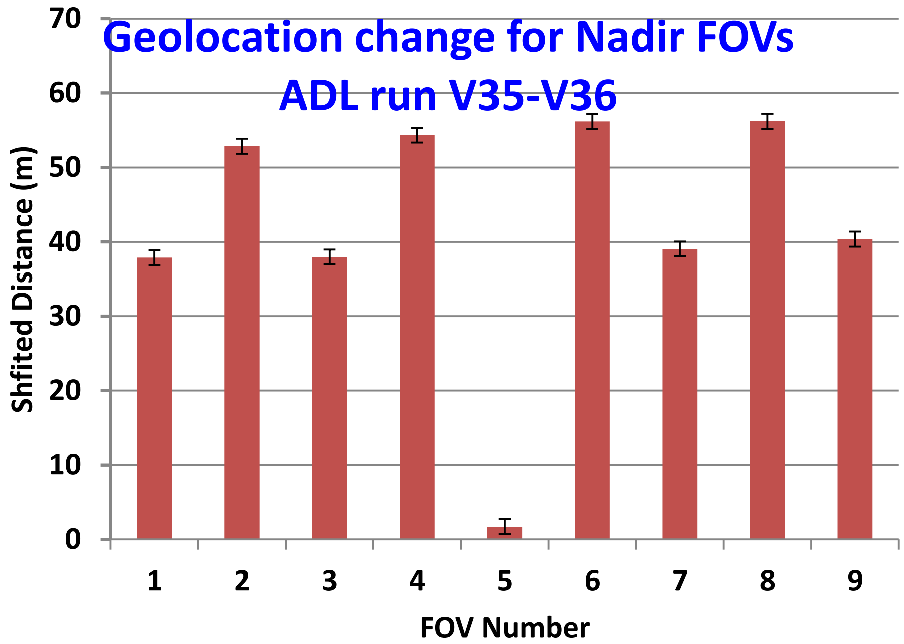
Band-to-Band Co-Registration (2)



- Three geolocation dataset were generated by ADL using LW, MW, and SW band detector angles, respectively.
- The distance was calculated by checking geolocation distance between LW and MW/SW bands for the different FOVs at nadir.
- For Nadir FOVs: Performance is less than 100 m (0.7%) of FOV size
  Specification is 196 m (1.4%) of FOV size

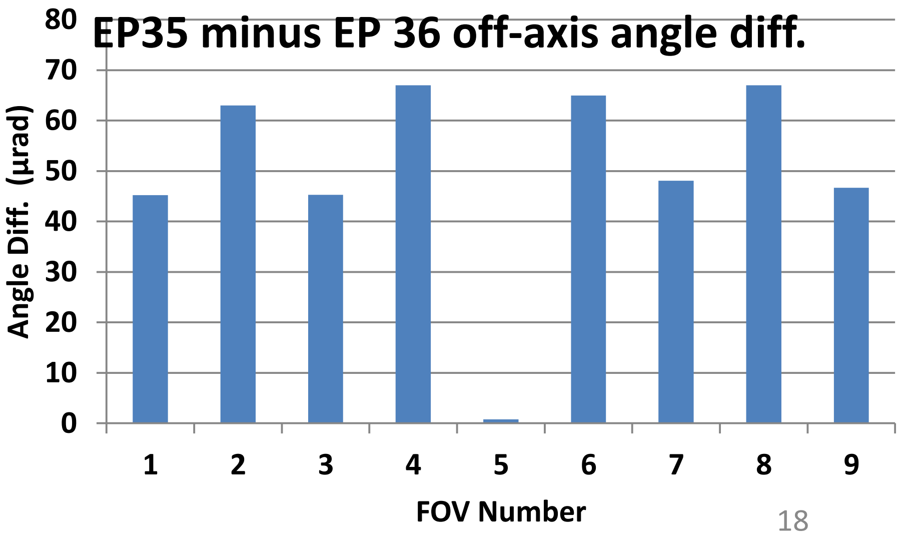
From EngPkt V35 to V36





Note only longwave detector angles are used for geolocation computations

FOV	V35 (longwave) crosstrack	V35 (longwave) intrack	V36 (longwave) Crosstrack	V36 (longwave) intrack
1	18784	19301	18751	19270
2	-359	19370	-359	19307
3	-19547	19346	-19514	19315
4	18792	158	18725	160
5	-359	158	-359	160
6	-19526	158	-19461	160
7	18809	-19010	18776	-18975
8	-359	-19049	-359	-18982
9	-19524	-19007	-19492	-18973



Conclusion and Future Work

- CrIS Geolocation performs well and is very stable since provisional review.

- Using VIIRS as a references:
  - At nadir: 0.354 ±0.047 km in scan direction and
    0.209 ± 0.082 km in track direction
  - Within 30 degree scan angles: less than 1.3 km

- Band-to-band co-registration meets the specification.

- From EP35 to EP36, the expected geolocation change is very small.

- Future work
  - Possible angle adjustment
  - Need evaluation for FORs above 30 scan angles