



# Assessment of Cloud Contamination in VIIRS Aerosol Products

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# Overview

- Short description of IDPS Aerosol Optical Depth product and some known issues.
- Data preparation and analysis
- Collocation results and findings
- Selected granule examples
- Summary

# VIIRS AOD (IDPS)

- AOD retrieved over dark surfaces at the M-band pixel level (750 m).
- Based on inputs (e.g. VCM) and internal checks, each pixel is assigned 1 of 4 quality flags (good, degraded, excluded, not produced).
- IP AOD is aggregated to EDR product by averaging all good and degraded pixels ('Top 2') within 8x8 box.
  - Top 40% and bottom 20% of AOD pixels not included in averaging to further mitigate effects of pixels contaminated by cloud, snow/ice, cloud shadow, etc.
- **Known Issues:**
  - VIIRS AOD has a slight positive bias over land, particularly at the IP level
  - Comparisons with other satellite AOD datasets show some seasonal/regional dependency on both AOD and data coverage.

# Analysis

- Datasets:
  - CALIPSO Cloud Layers -1 km, 30m vert.
  - VIIRS Cloud Mask (VCM) – 750 m
  - VIIRS Aerosol Optical Depth – 750 m (IP), 6 km (EDR)
- CALIPSO cloud info used to examine VCM errors and the role they play in AOD retrieval.
  - If the number of cloud layers detected in the CALIPSO profile  $\geq 1$  then it is deemed 'cloudy'.
  - VIIRS 4-tier cloud mask converted to binary mask
    - Probably and Confidently Cloudy -> Cloudy
    - Probably and Confidently Clear -> Clear
  - Observations from CALIPSO and VIIRS must be within 5 minutes and within 750 m of one another to be considered a match.

# Results of CALIPSO matchups

Feb '13 - Feb'14		VIIRS	
CALIPSO		Cloudy	Clear
	Cloudy	65079	14482
	Clear	4129	47298

Accuracy: 86%

- VIIRS exhibits a large number of false-clear (FC) detections, where VCM says 'clear' but CALIPSO says 'cloudy'.
- 23.4% of VIIRS aerosol retrievals could potentially be cloud contaminated. (False Clear/Total Clear)
- 66% of the FC matches were labeled 'confidently clear' by VCM.

# FC pixel qualities

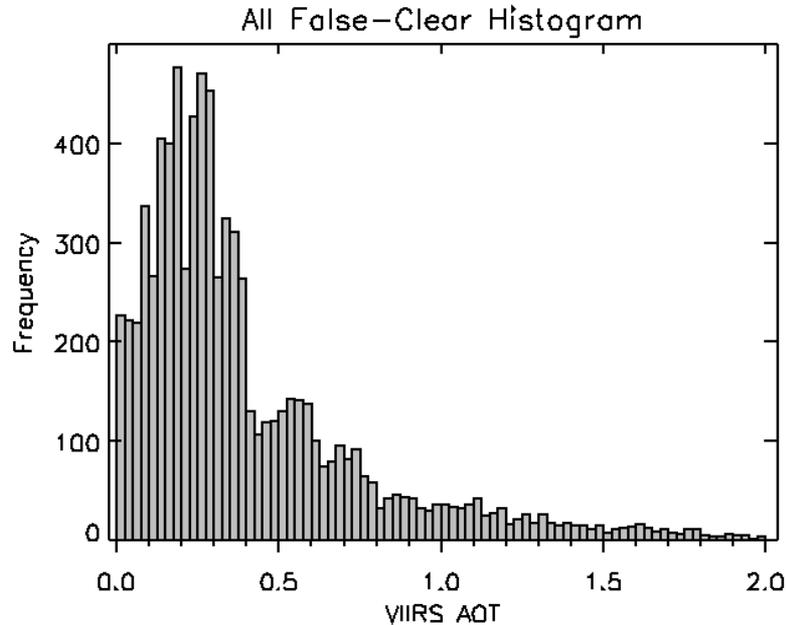
IP Flag	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Total
Good	130	51	122	74	165	215	329	162	51	89	56	152	<b>1596</b>
Degraded	388	319	549	362	583	903	1143	410	569	567	298	279	<b>6370</b>
Excluded	13	17	104	76	74	112	151	114	232	204	142	261	<b>1500</b>
Not Produced	929	846	219	341	316	157	192	66	96	423	835	596	<b>5016</b>
<b>TOTAL</b>	<b>1460</b>	<b>1233</b>	<b>994</b>	<b>853</b>	<b>1138</b>	<b>1387</b>	<b>1815</b>	<b>752</b>	<b>948</b>	<b>1283</b>	<b>1331</b>	<b>1288</b>	<b>14482</b>

**7966**

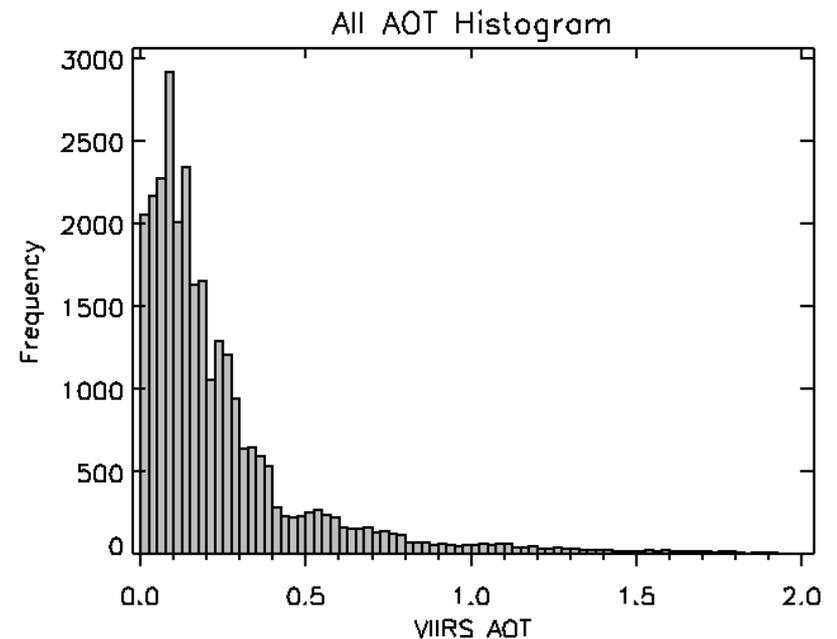
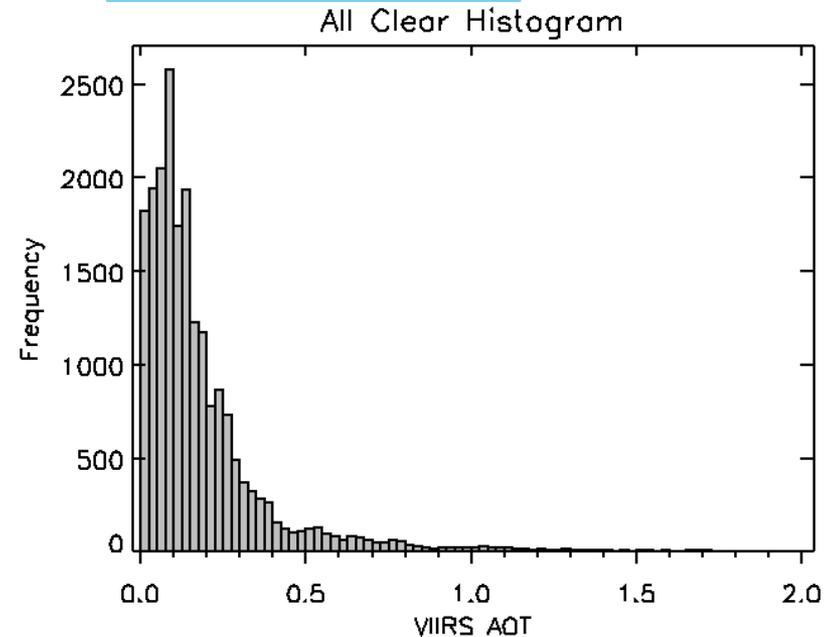
EDR Flag	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Total
High	56	32	55	35	87	130	155	124	34	60	25	56	<b>849</b>
Medium	127	128	213	118	205	335	364	134	199	154	86	83	<b>2146</b>
Low	56	74	80	76	58	135	121	87	122	110	89	72	<b>1081</b>
Not Produced	337	251	68	95	134	35	56	9	29	106	298	158	<b>1577</b>
<b>TOTAL</b>	<b>576</b>	<b>485</b>	<b>416</b>	<b>325</b>	<b>484</b>	<b>635</b>	<b>696</b>	<b>354</b>	<b>384</b>	<b>430</b>	<b>498</b>	<b>370</b>	<b>5653</b>

**2995**

# AOD distribution



- Small but noticeable increase in high AOD values when comparing FC to clear retrievals.
- Average AOD of FC pixels is about 0.06 higher than remaining pixels



# Initial discoveries

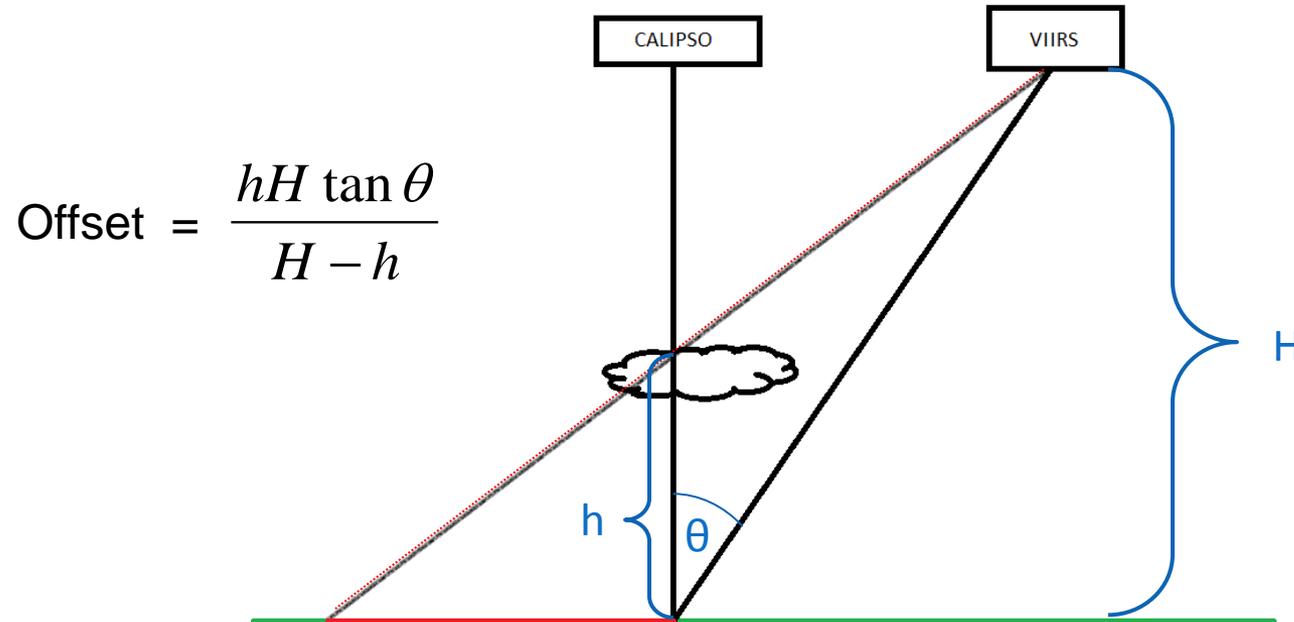
- Higher number of confidently clear pixels are found to be contaminated.
- Factoring in quality level, the number of potentially contaminated pixels is reduced from 14482 to 7966 (45% reduction)
  - Affected EDR pixels similarly decrease by 47%.
  - This means that approximately 12% of aerosol retrievals could still be impacted by clouds.
- The false-clear pixels cause an increase in the number of high-AOD retrievals, and some widening of the AOD distribution at moderate AOD.

# Digging deeper

- Pixel-level quality and internal checks are not the only line of defense.
- Aggregation to the EDR includes further quality checks and filtering to reduce effects from clouds and other adverse retrieval conditions.
  - If number of top 2 IP pixels in 8x8 box  $> 16$ , then filtering takes place based on retrieved AOD using 40/20 rule.
  - We can see which pixels are removed when we follow the FC pixels through the aggregation process.
  - Overall 3763 additional FC pixels are discarded (3196 in top 40%, 567 in bottom 20%) – **Only benefits EDR however**



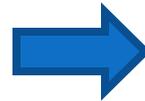
# Satellite Parallax



- Calculate offset using cloud top height ( $h$ ) along with altitude ( $H$ ) and viewing angle ( $\theta$ ) of VIIRS (Wang and Huang, 2014)
- The shift in ground location will increase as  $h$  and  $\theta$  increase.

# Pixel counts when accounting for parallax

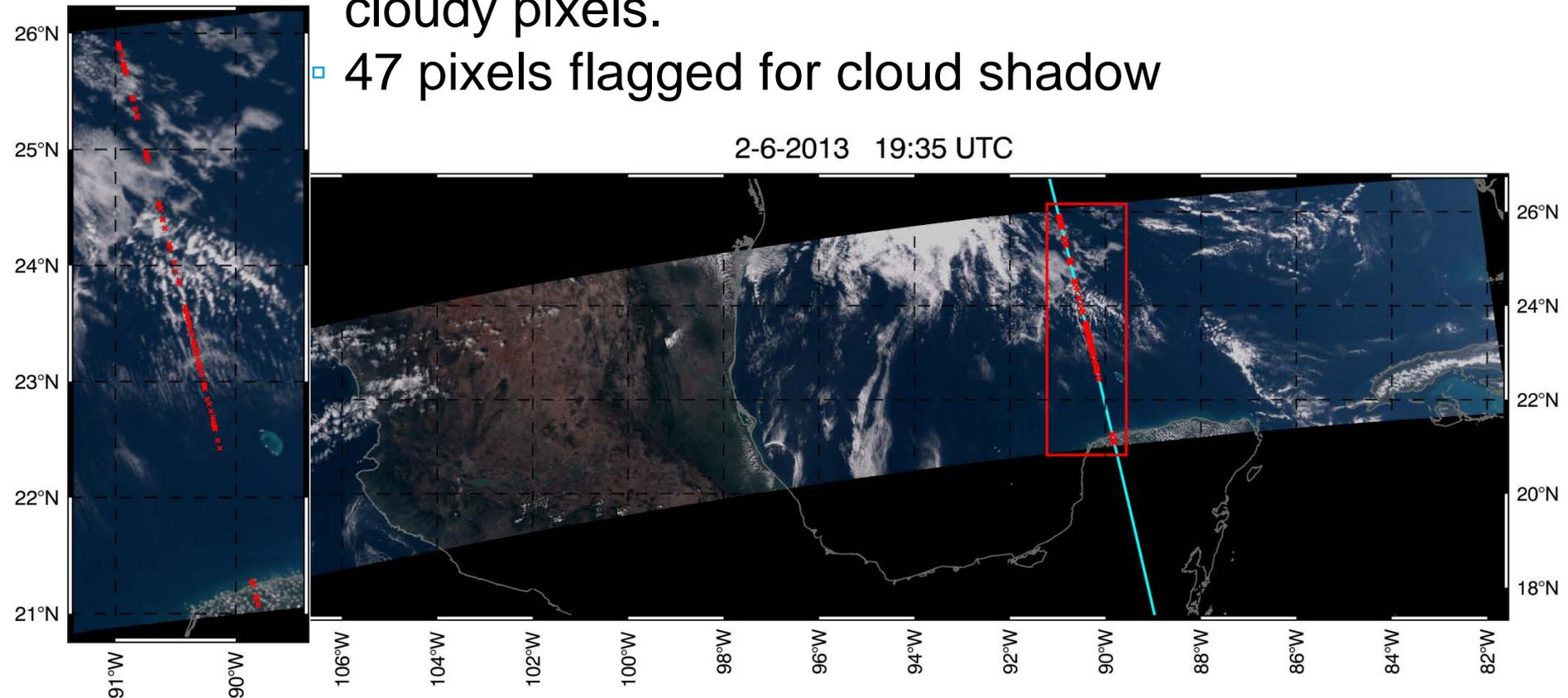
- Allowing for a maximum offset of 0.75 km reduces number of FC pixels by 85-95%.
- Doesn't necessarily mean those pixels with greater offset are not contaminated.
- Ratio of conf. clear to prob. clear pixels now closer to what we expect.



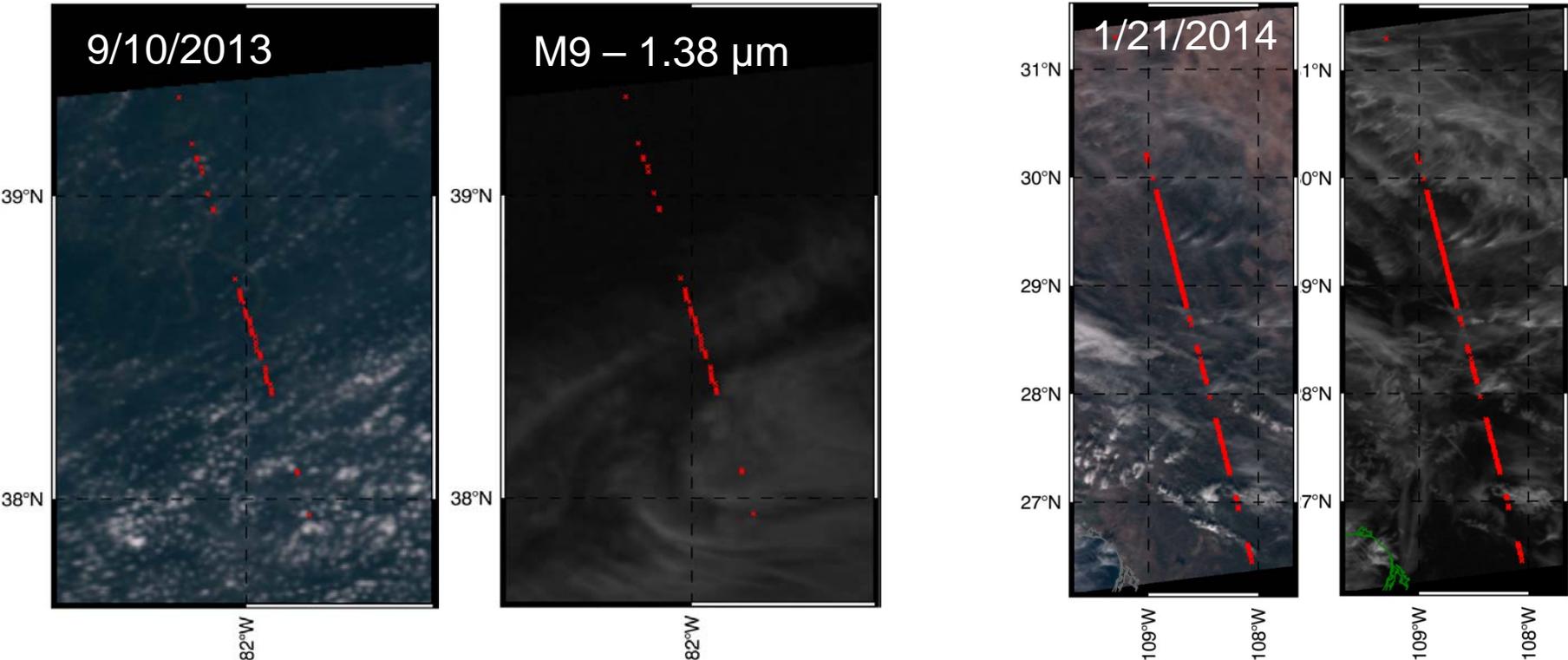
False-Clear parameter	No Parallax check	0.75 km Max Offset
IP-Good	1596	141
IP-Degraded	6370	414
IP-Excluded	1500	36
IP-Not Produced	5016	488
<b>Confidently Clear</b>	9547	508
<b>Probably Clear</b>	4935	573
<b>Top 40%</b>	3196	246
<b>Bottom 20%</b>	567	34
<b>EDR-High</b>	849	139
<b>EDR-Medium</b>	2146	164
<b>EDR-Low</b>	1081	64
<b>EDR-Not Produced</b>	1577	223

# Specific cases – Scattered Cloud Field

- 94 total FC pixels
  - VCM: 17 conf. clear, 77 prob. Clear
  - 81 of the FC pixels are largely surrounded by cloudy pixels.
  - 47 pixels flagged for cloud shadow



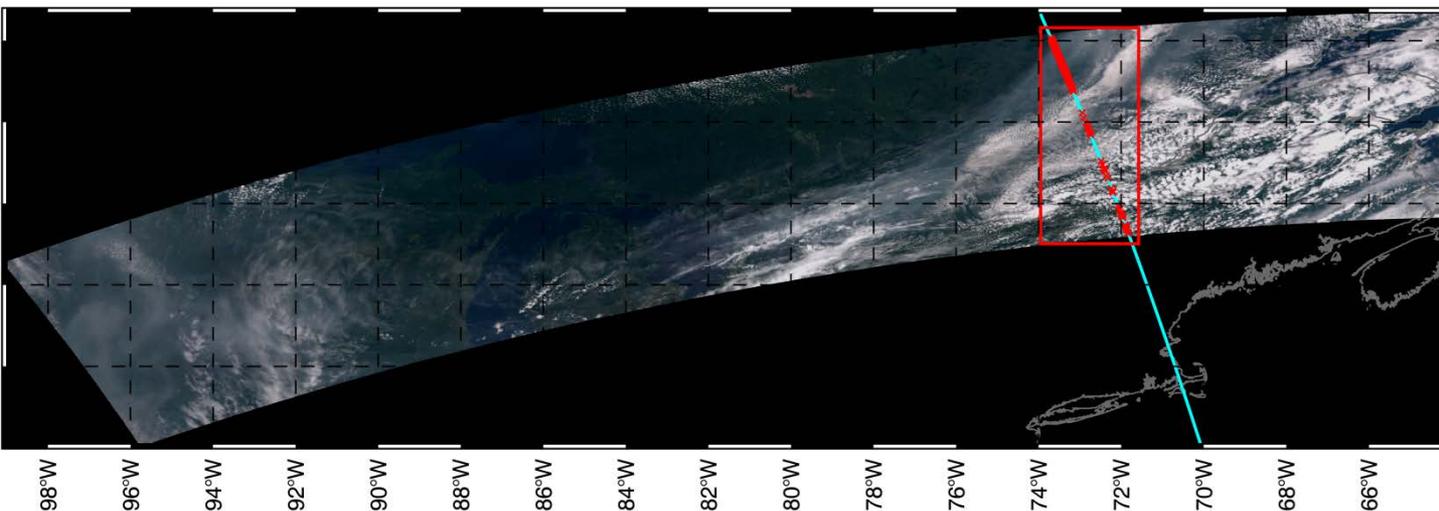
# Specific Cases - Cirrus



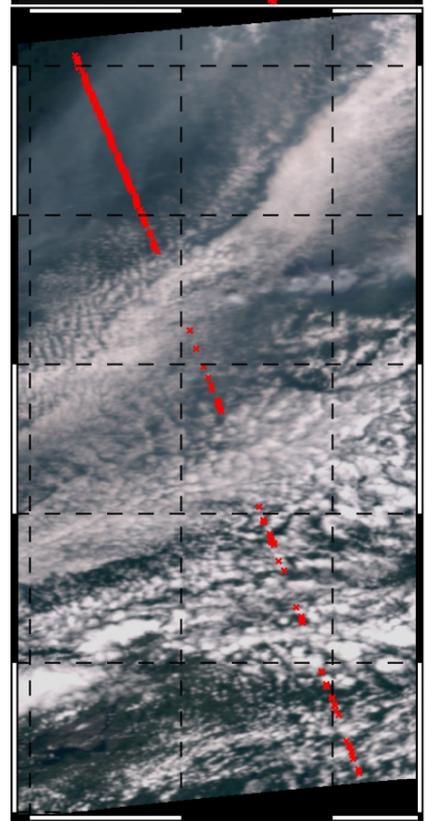
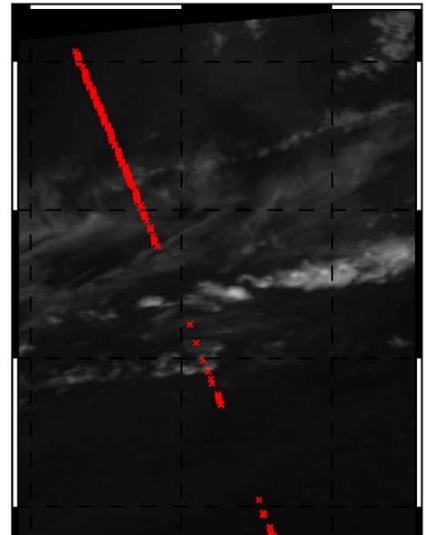
- Most FC pixels and surrounding pixels flagged as 'clear'.
- Sept. 10: 0 pixels flagged for cirrus; Jan 21: 22 out of 210 flagged for cirrus
- Detection of thin cirrus by VCM or Aerosol alg. may not be able to match higher sensitivity of CALIPSO.

# Mixed Aerosol/Clouds

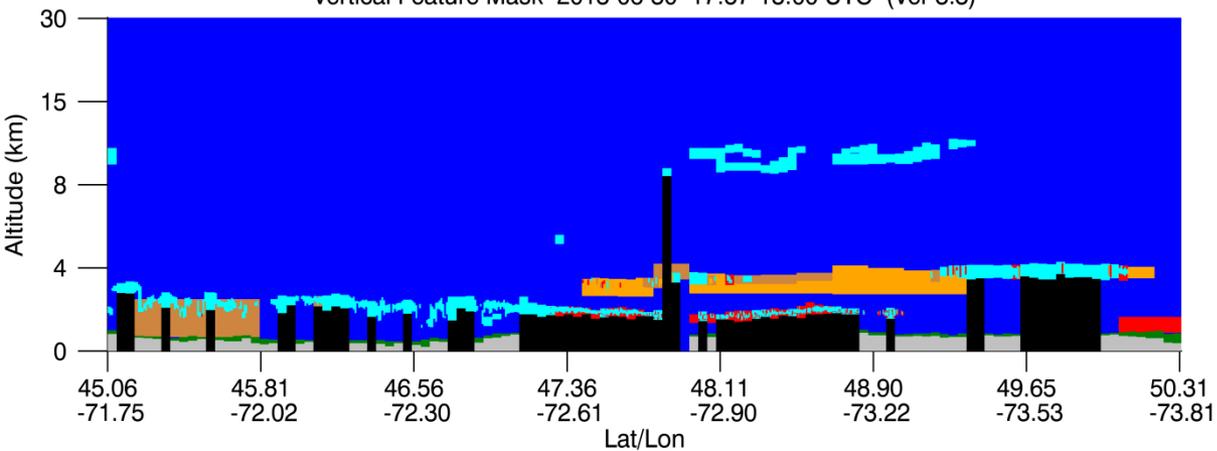
6-30-2013 18:02 UTC



50°N  
49°N  
48°N  
47°N  
50°N  
49°N  
48°N  
47°N  
46°N  
45°N



Vertical Feature Mask 2013-06-30 17:57-18:00 UTC (Ver 3.3)



- Low Conf. Aerosol
- Low Conf. Cloud
- No Signal
- Sub-surface
- Surface
- Stratospheric
- Aerosol
- Cloud
- Clear

74°W  
73°W  
72°W

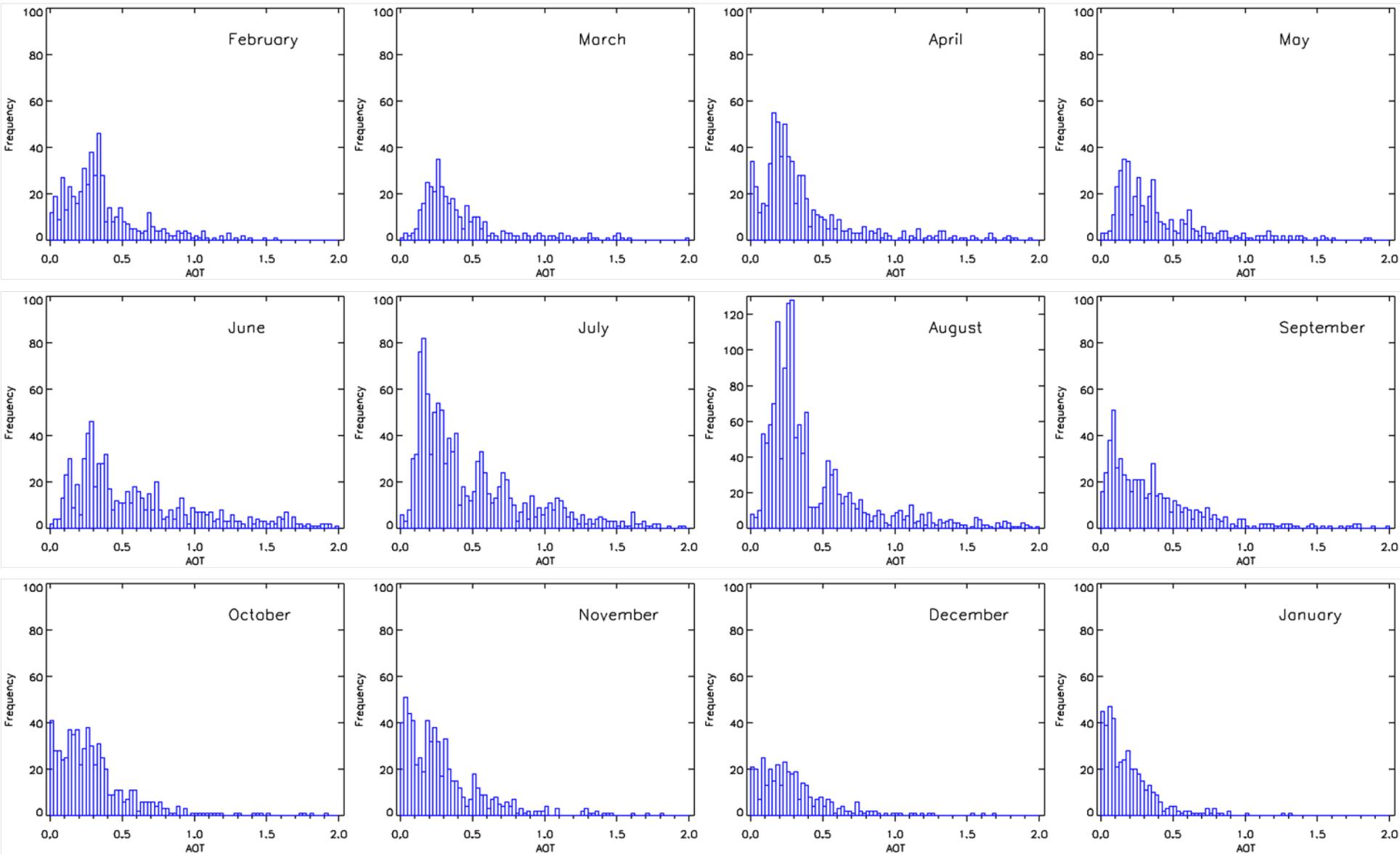
# Summary

- Based on matchups with CALIPSO, approximately a quarter of VIIRS aerosol retrievals could potentially be cloud contaminated.
- Nearly half (45%) of these FC matchups however are not top-2 quality and therefore are not impacting the EDR product.
- In addition, a large percentage (47%) of FC with top-2 quality are removed during aggregation.
- Taking into account quality designation and aggregation, the maximum cloud contamination would be around 7% for this time period.
- Cirrus clouds and mixed/ambiguous scenes potential contributors to remaining cloud contamination.

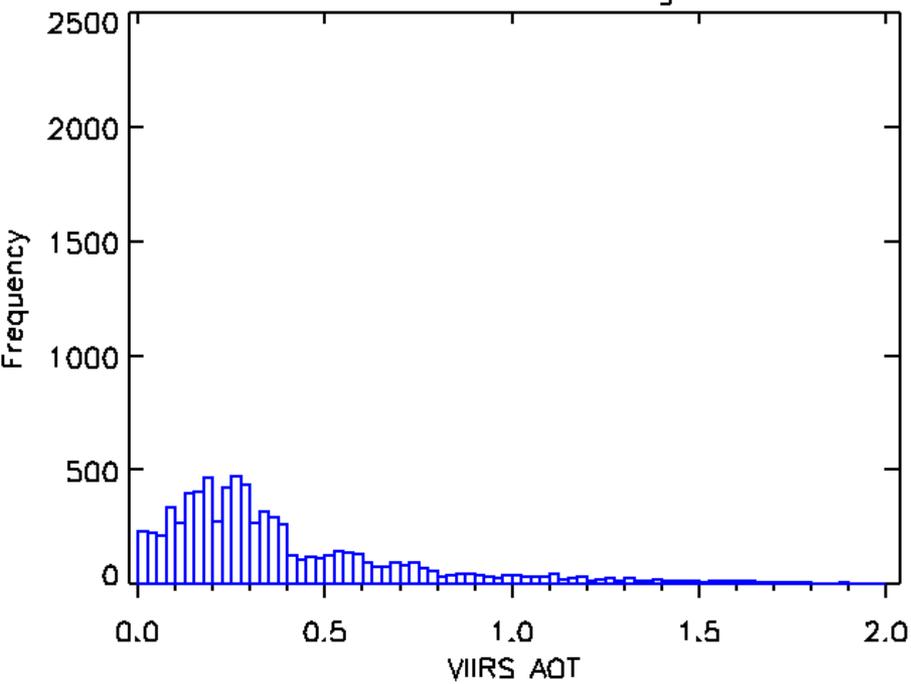
# THANK YOU!

- Questions?

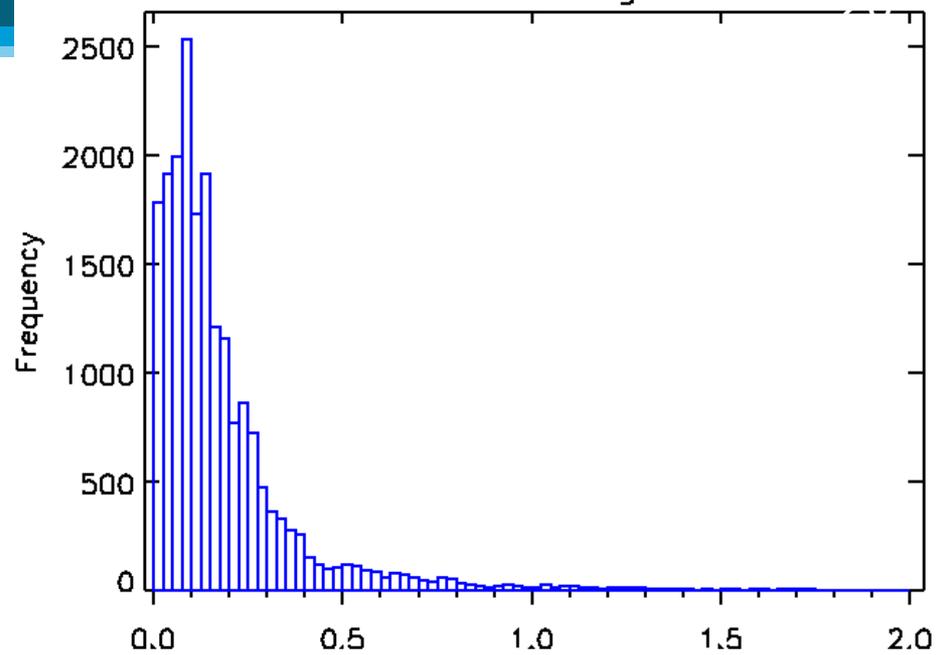
# Additional Slides



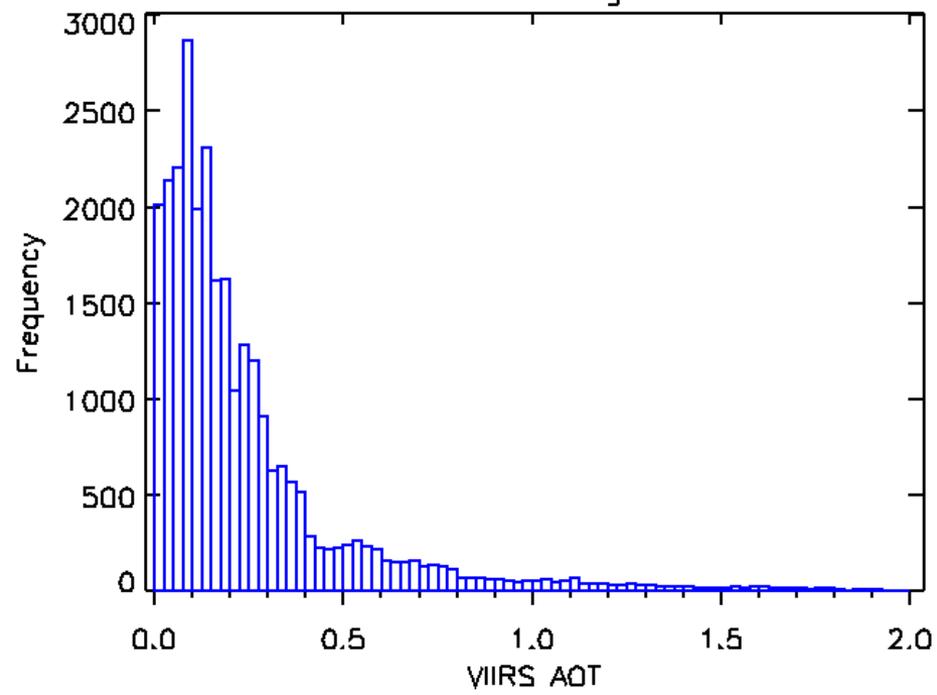
All False-Clear Histogram



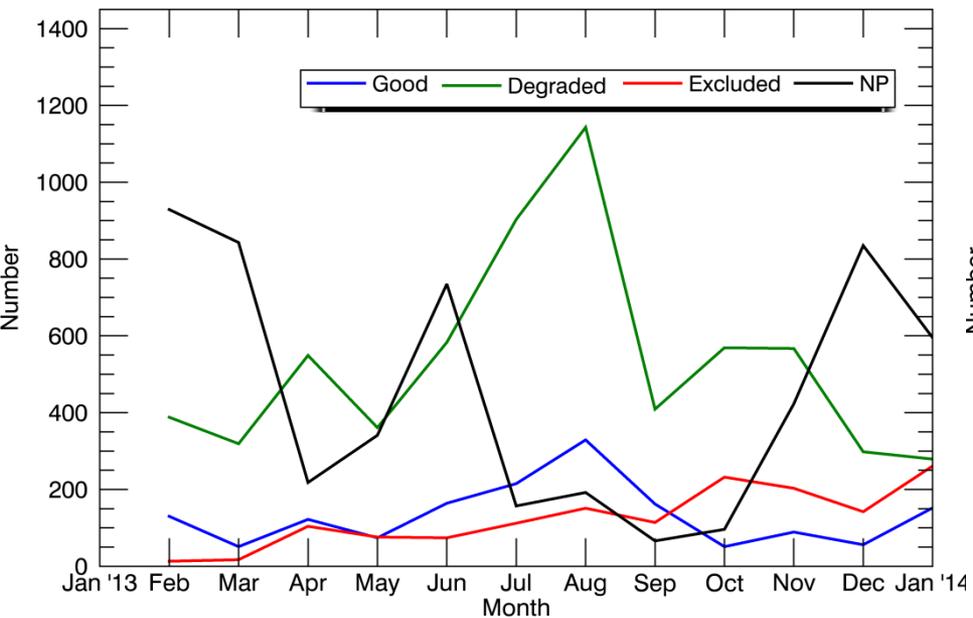
All Clear Histogram



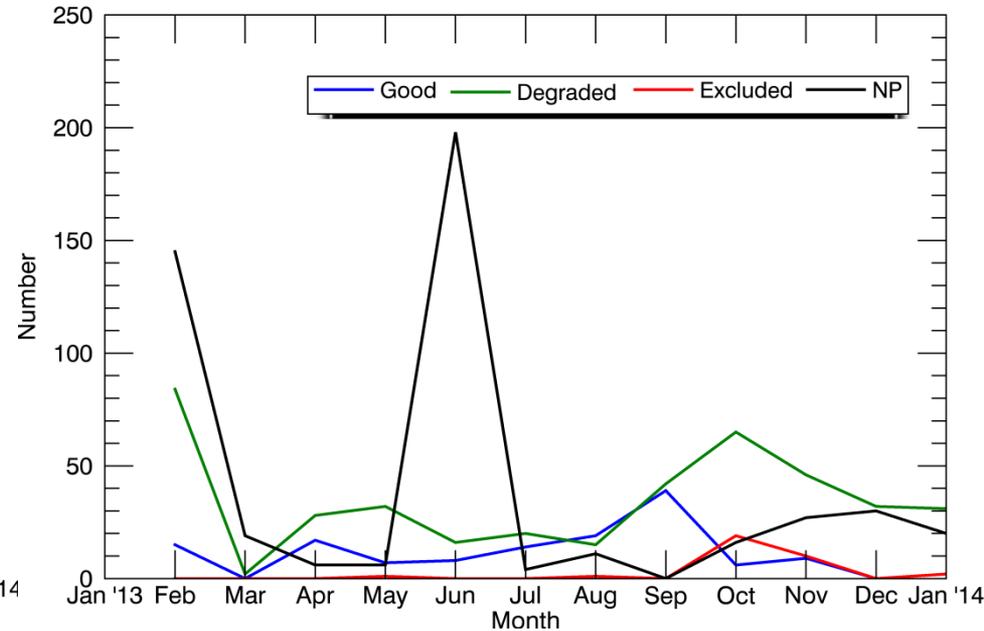
All AOT Histogram



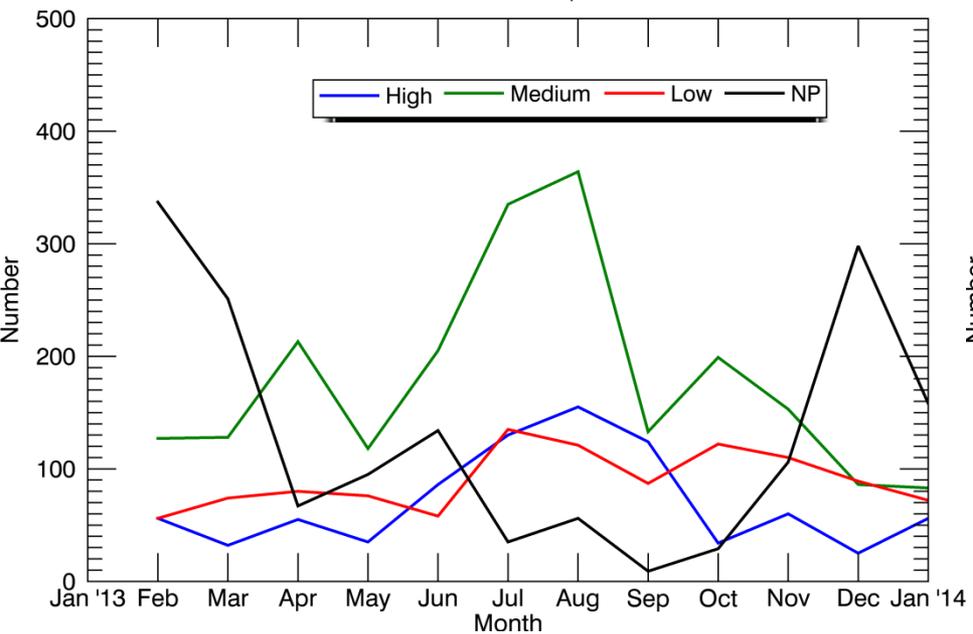
IP False Clear pixels



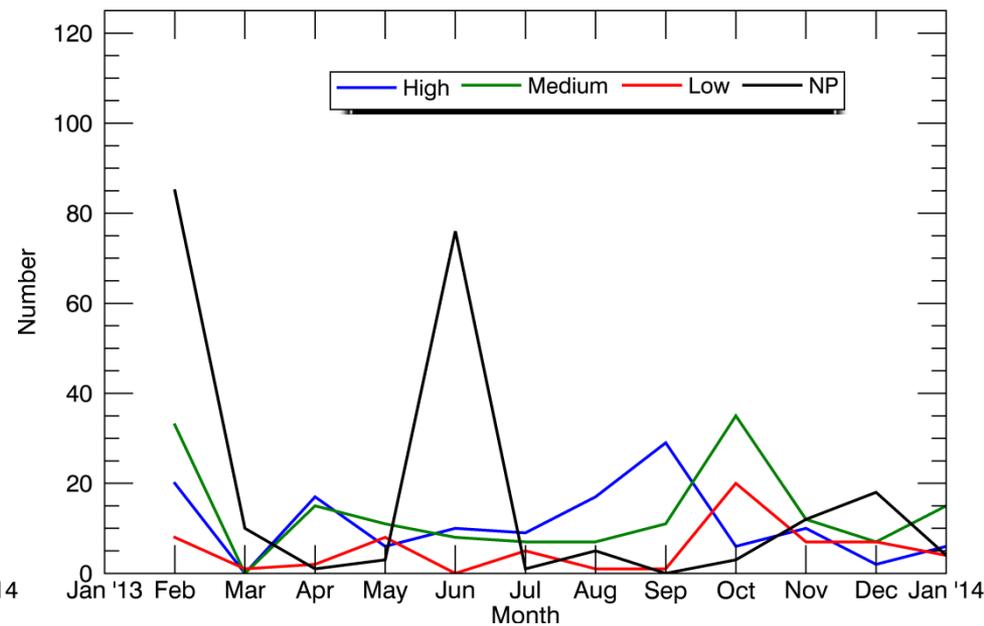
IP False Clear pixels (0.75 km Offset)

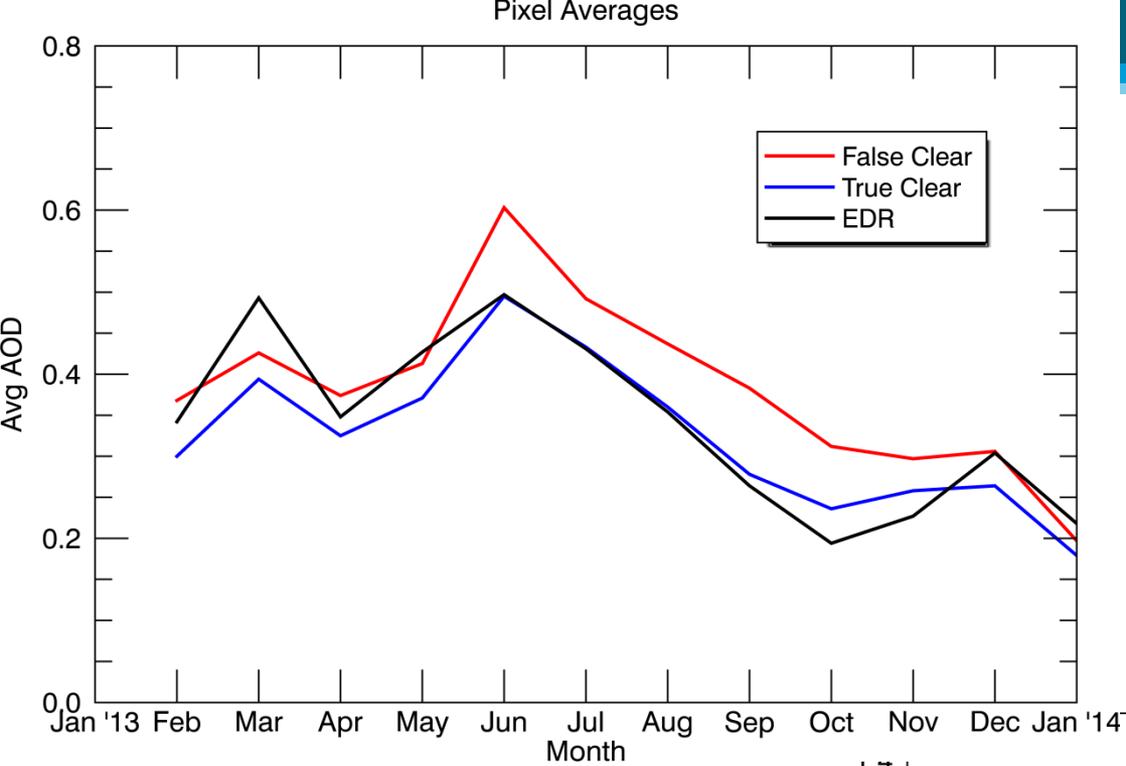


EDR False Clear pixels



EDR False Clear pixels (0.75 km Offset)





Pixel Averages .75 max offset

