

The Absolute and Relative Geolocation Accuracies of QB02 and WV01

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DigitalGlobe

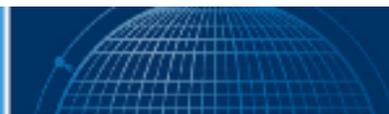


outline

- methods
 - gcps
 - geocal sites
- absolute geolocation accuracy for QB02 and WV01
 - nadir projected error
 - desired accuracy
 - percentiles, CCAP metric
 - absolute accuracy by quarter
- relative geolocation accuracy for QB02 and WV01
 - relative error definition
 - relative accuracy by quarter using ordinary data
 - relative accuracy by quarter using **detrended** data



methods

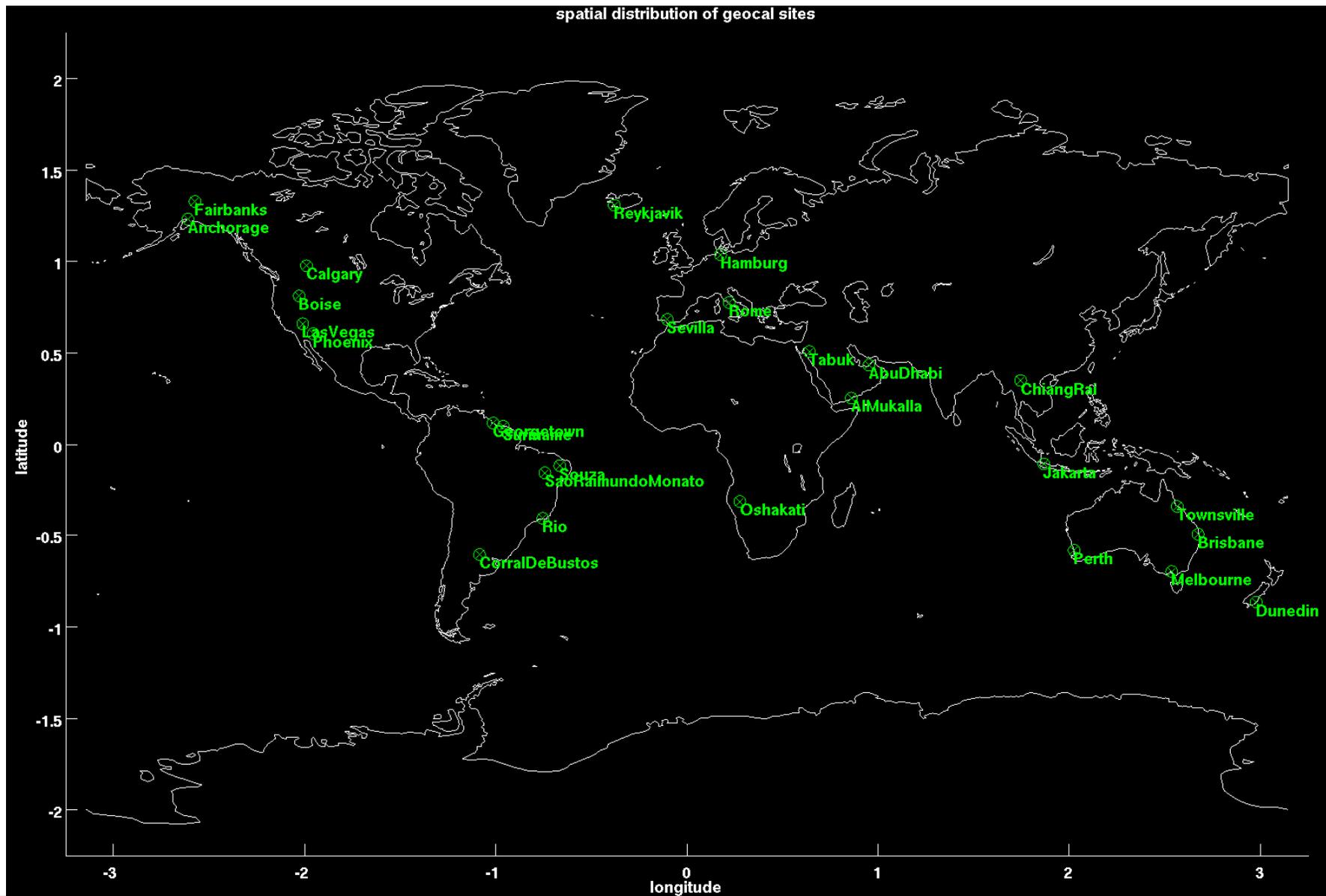


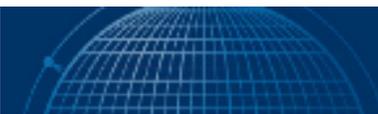
gcps are used to assess absolute geolocation accuracy

- each city/area has a set of GPS surveyed gcps, call it a *(geo)metric (cal)ibration site*
- each geocal site has ngcps
- multiple geocal sites are used to assess accuracy

27 sites	
<u>site</u>	<u>ngcp</u>
Abu Dhabi, United Arab Emirates	15
Al Mukalla, Yemen	10
Anchorage, Alaska	19
Boise, Idaho	14
Brisbane, Australia	15
Calgary, Alberta	11
Chiang Rai, Thailand	21
Corral De Bustos, Argentina	15
Dunedin, New Zealand	10
Fairbanks, Alaska	21
Georgetown, Guyana	10
Hamburg, Germany	11
Jakarta, Indonesia	10
Las Vegas, Nevada	47
Melbourne, Australia	25
Oshakati, Namabia	15
Perth, Australia	82
Phoenix, Arizona	113
Reykjavik, Iceland	9
Rio de Janeiro, Brazil	20
Rome, Italy	10
Sao Raimundo Monato, Brazil	15
Paramaribo, Suriname	16
Sevilla, Spain	10
Souza, Brazil	15
Tabuk, Saudi Arabia	10
Townsville, Australia	20

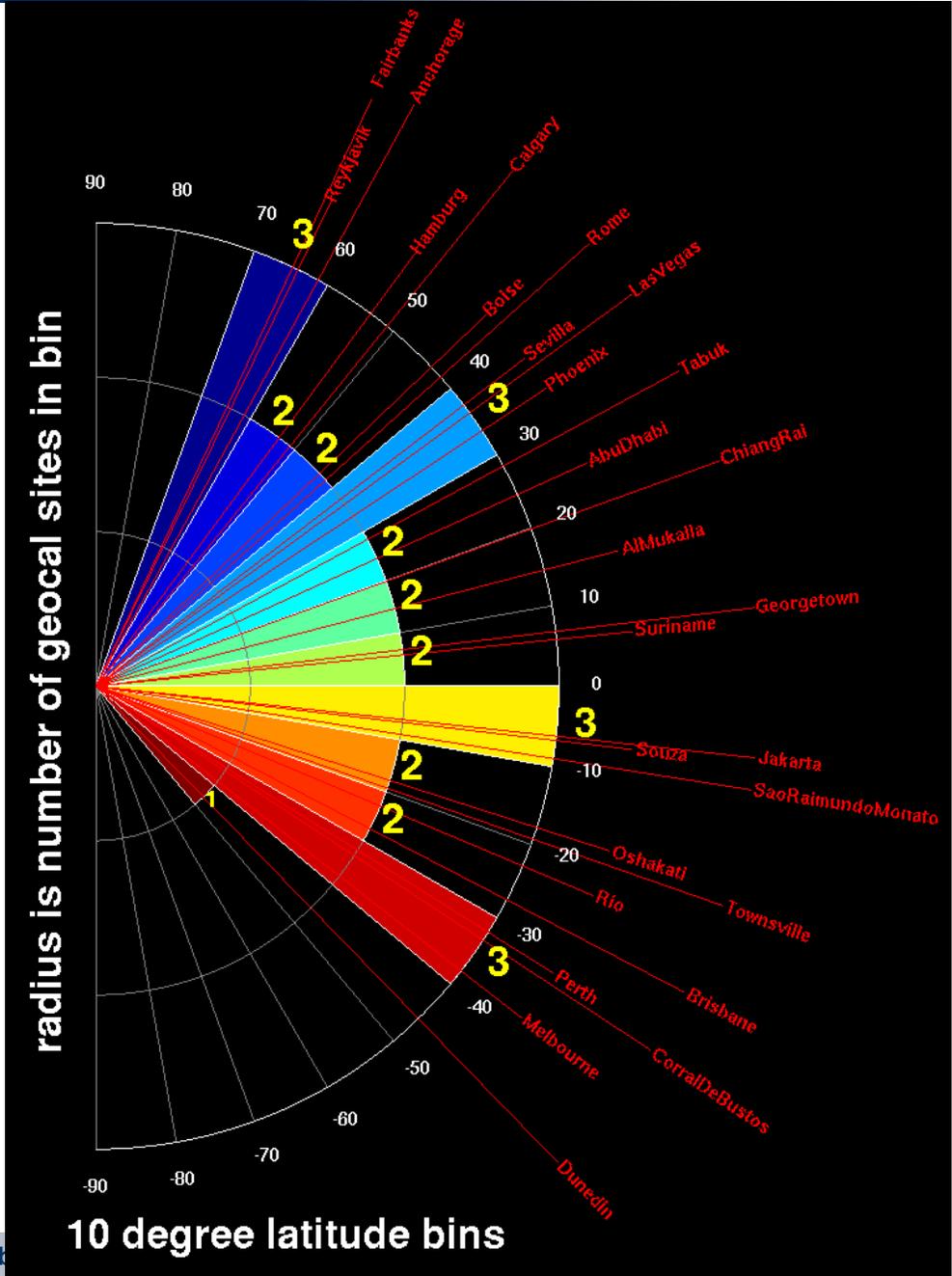
geocal sites in use as of March 2009





angular histogram of geocal sites as of March 2009

(almost) two sites
every ten degrees
of latitude



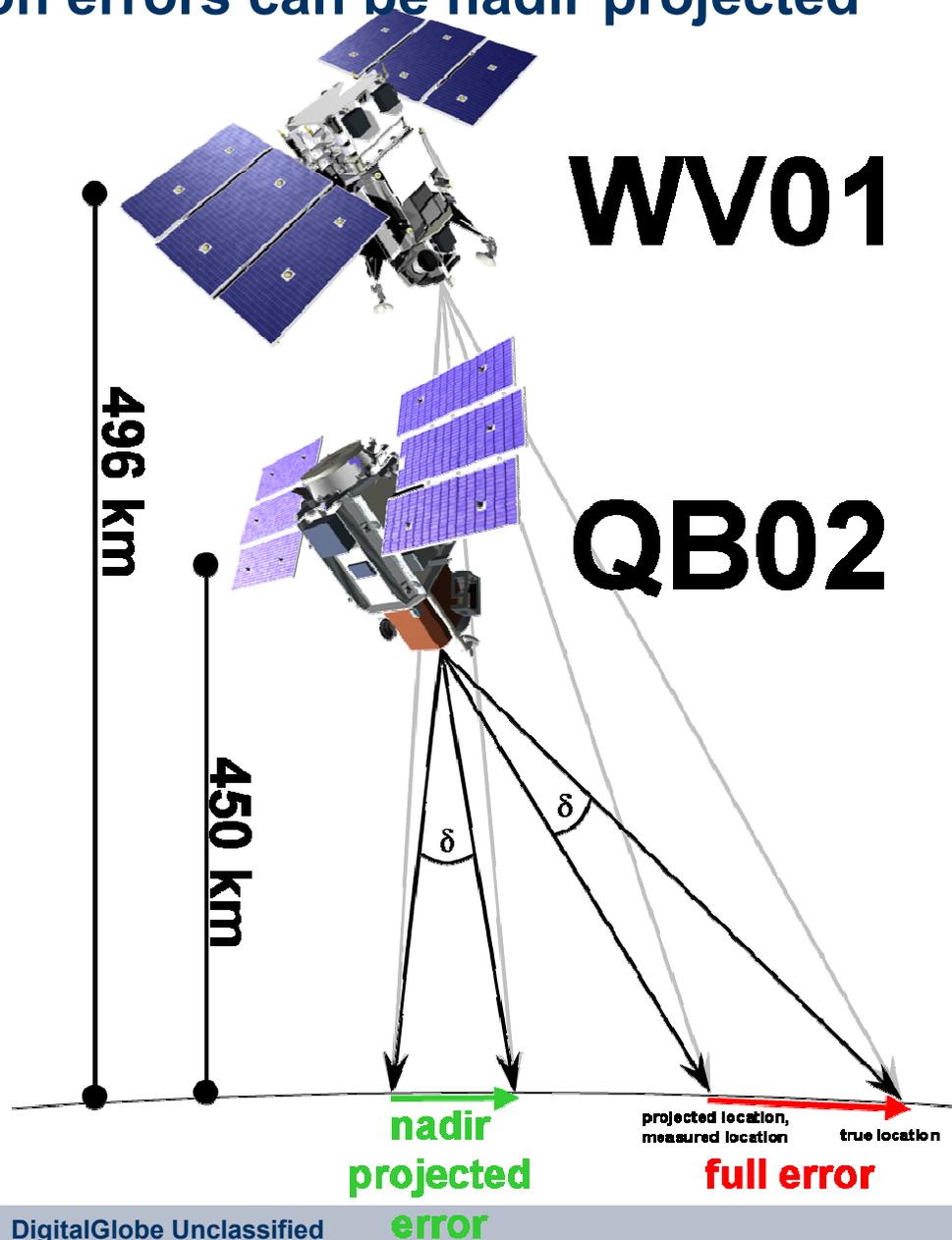


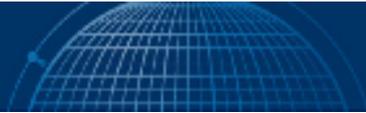
Absolute Geolocation Accuracy

absolute geolocation errors can be nadir projected

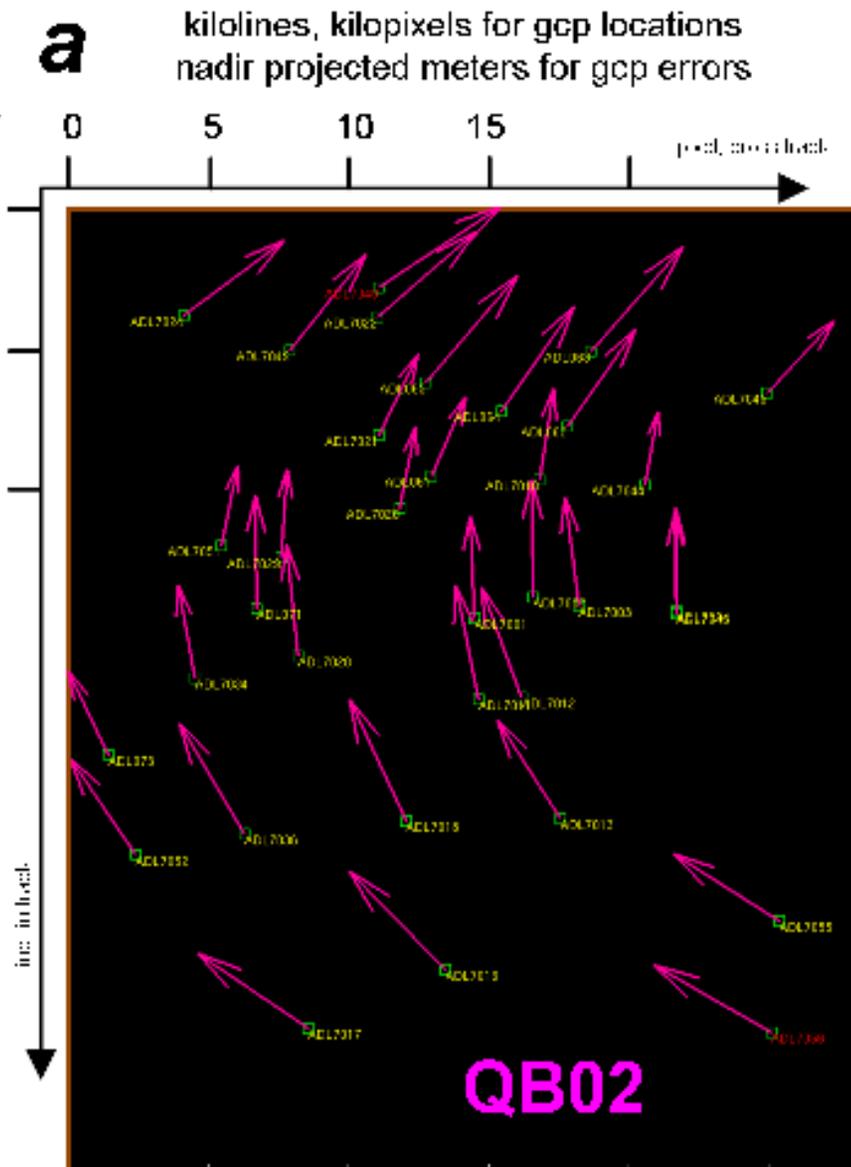
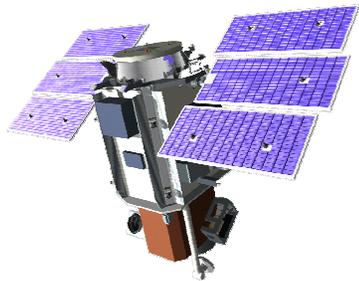
nadir projection helps
compare images from
different nadir angles

*desired geolocation accuracy
also defined in terms of
nadir projected error*

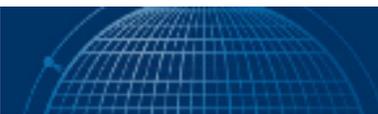




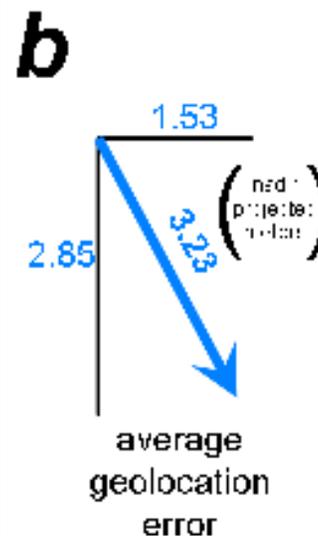
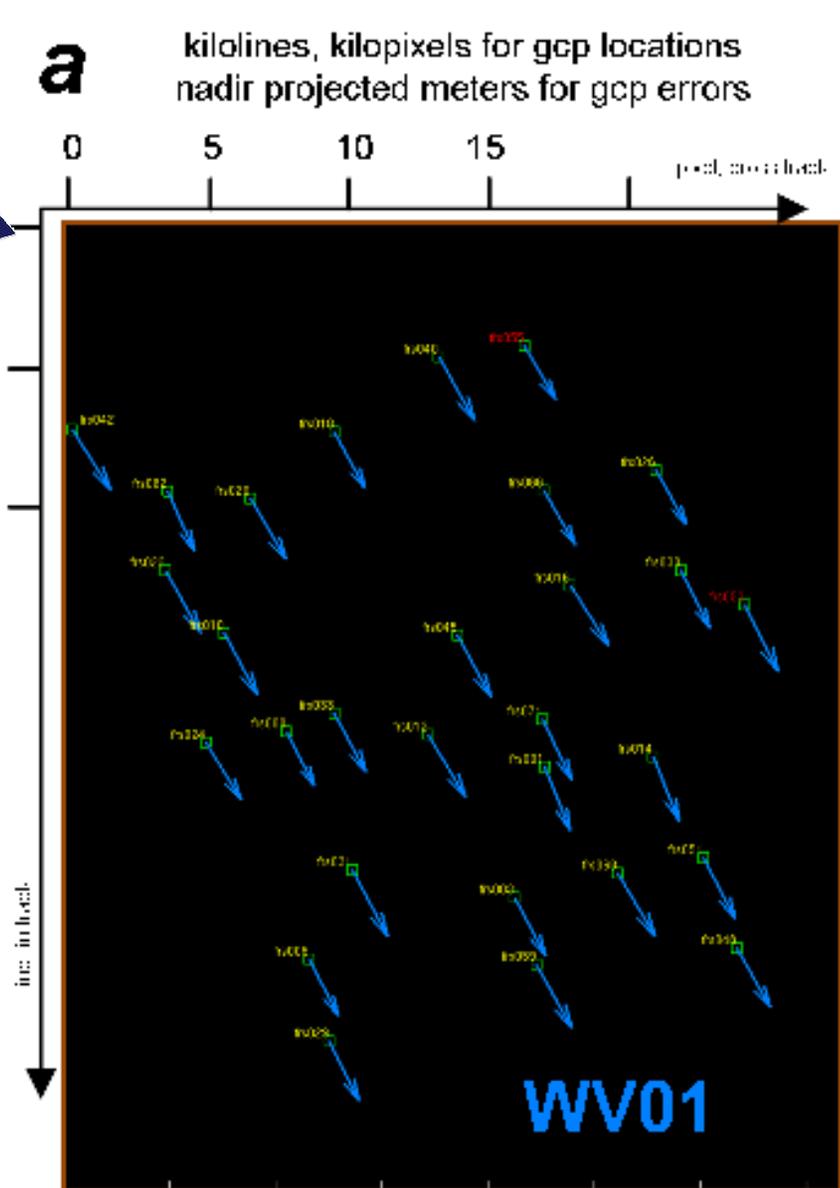
absolute geolocation errors can be assembled into a quiver plot



absolute accuracy can be summarized by the **average geolocation error**



absolute geolocation errors can be assembled into a quiver plot



absolute accuracy can be summarized by the **average geolocation error**

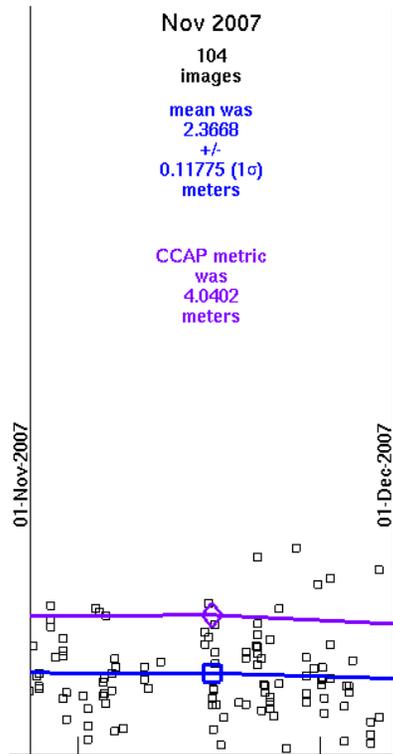
desired absolute geolocation accuracy

90th percentile of something, everything should be

23 meters (projected to nadir) for **QB02**

6.5 meters (projected to nadir) for **WV01**

this 90th percentile is used for evaluation



if you represent each
strip by the magnitude
of the average error,
then take the NGA 90th
percentile of a bin,

that's the
CCAP metric.

- Say there are N errors, r_1 to r_N
- Multiply N by 0.9, express result as an integer plus a fraction:

$$N*0.9 + 0.5 = i + f$$

- Stand f of the way between r_i and r_{i+1}

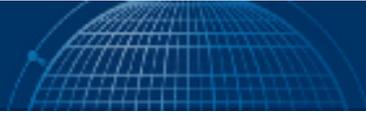
$$CE90 = r_i + (r_{i+1} - r_i)*f$$

- I call it NGA percentile in this talk

[1 2 3 4 5 6 7 8 9 10]



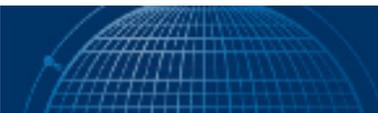
NGA percentile: if you have ten things, the 90th percentile is halfway between the ninth and tenth thing (it's unbiased, by construction through Monte Carlo studies)



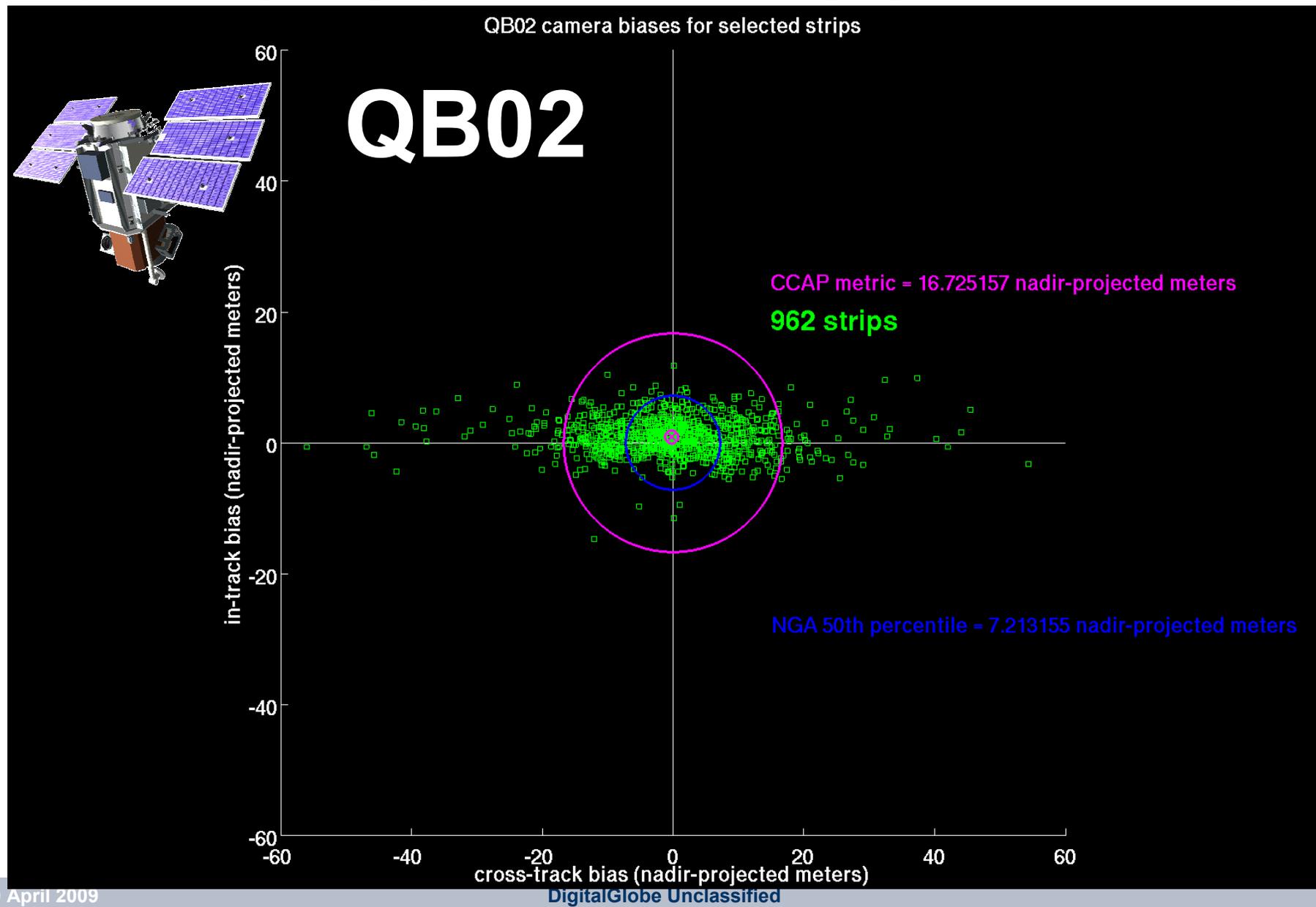
Absolute Geolocation

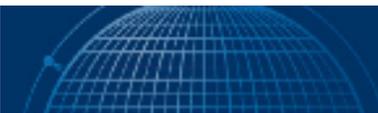
Accuracy

scatter with percentiles

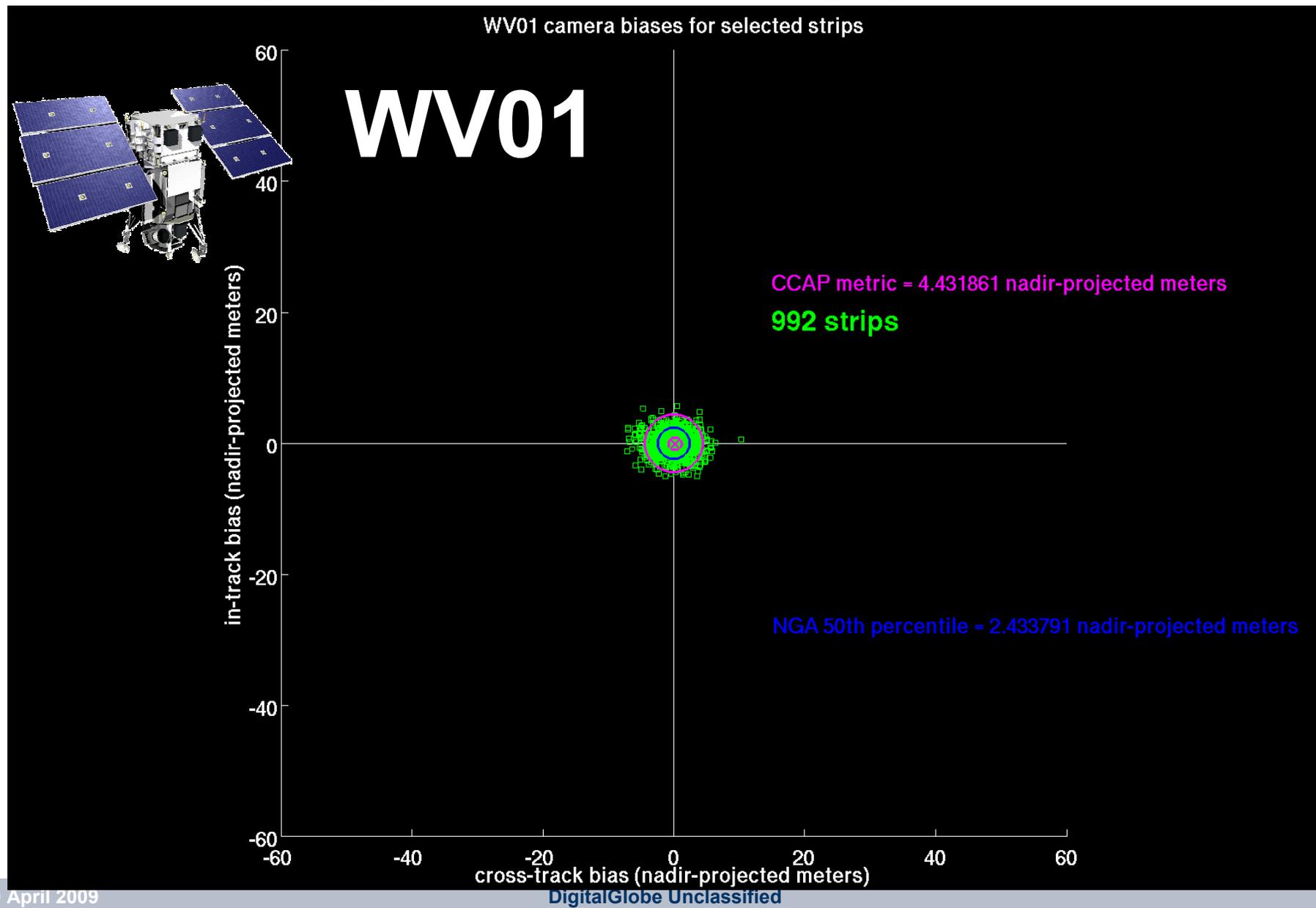


plot everything! (at location of average geolocation error)

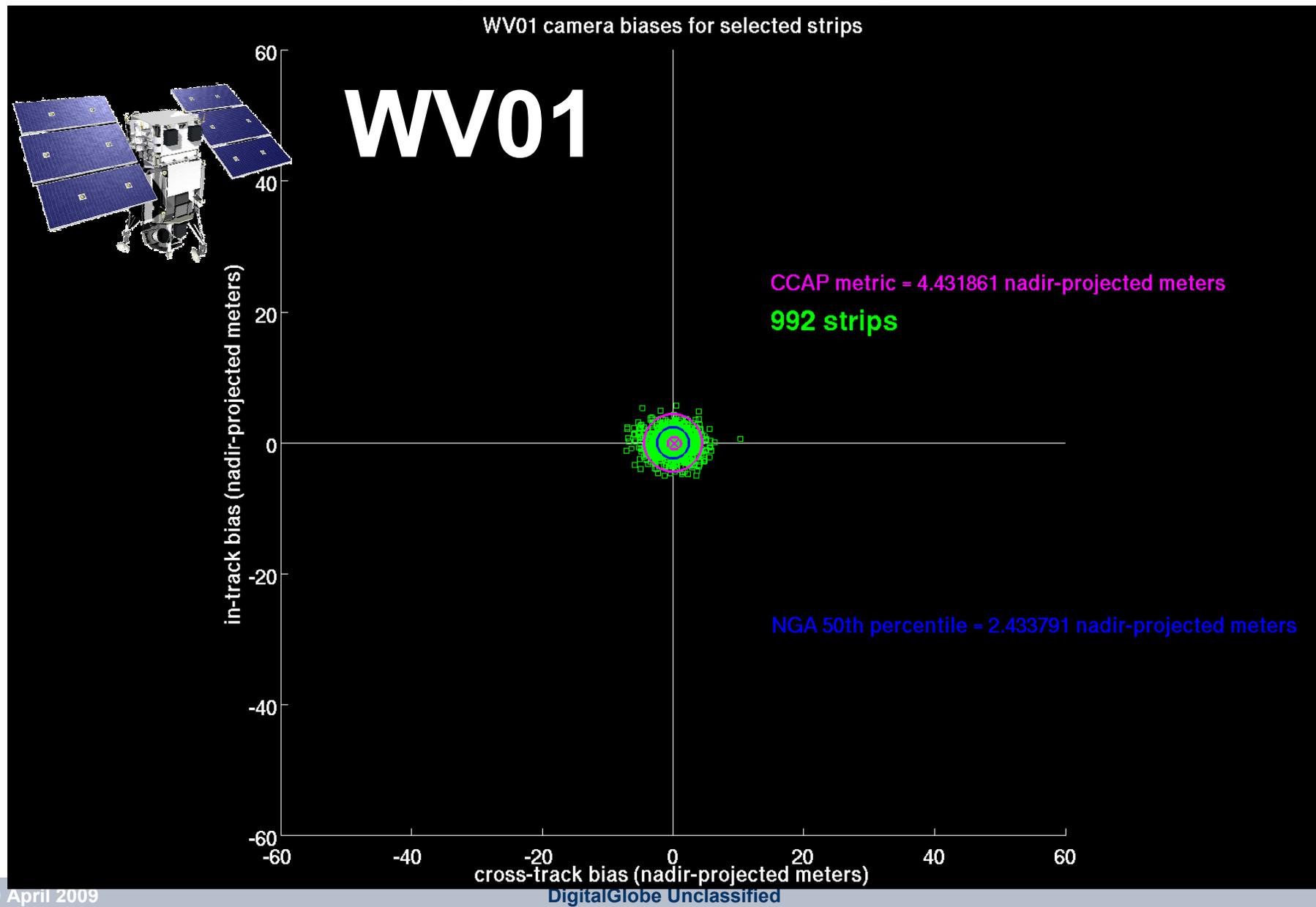


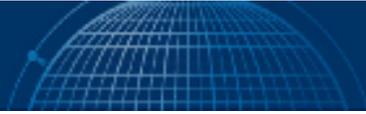


plot everything! (at location of average geolocation error)



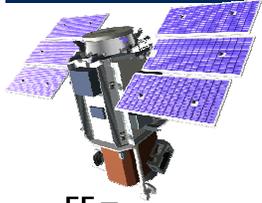
flicker plot of scatter for emphasis





Absolute Geolocation Accuracy

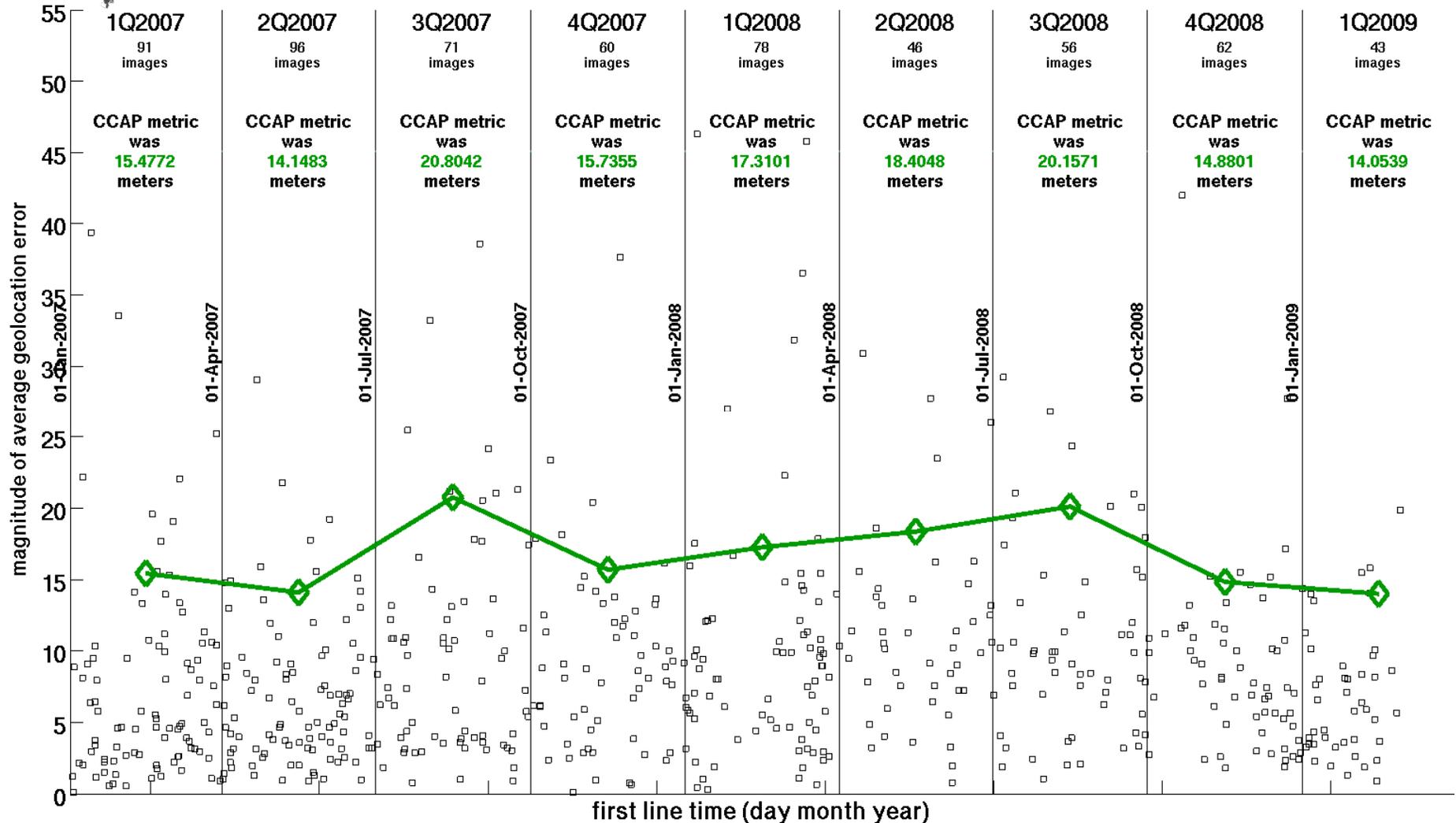
quarters with percentiles

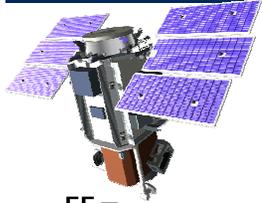


absolute geolocation accuracy by quarter

QB02

nadir projected errors

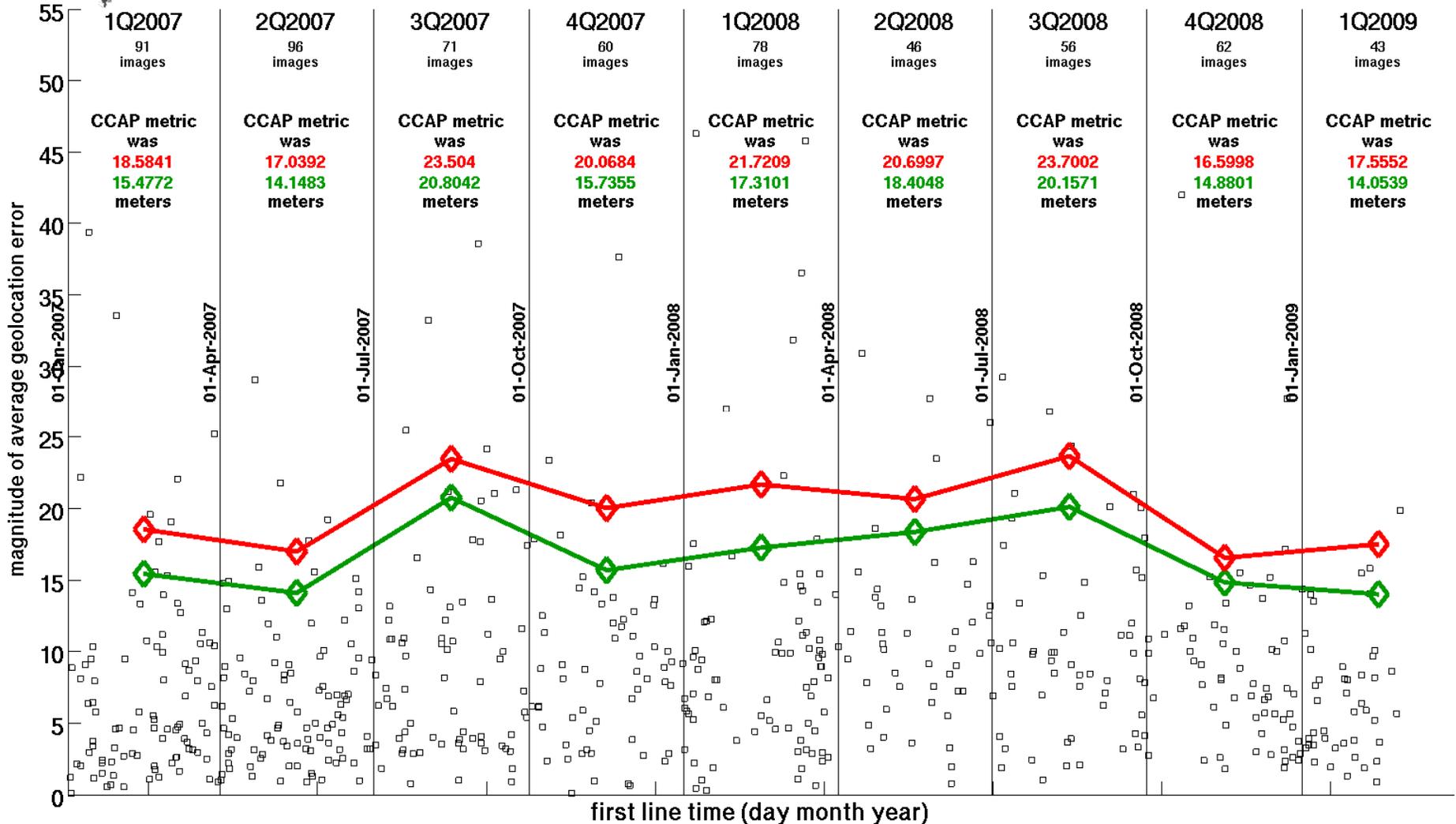




absolute geolocation accuracy by quarter

QB02

full errors
nadir projected errors

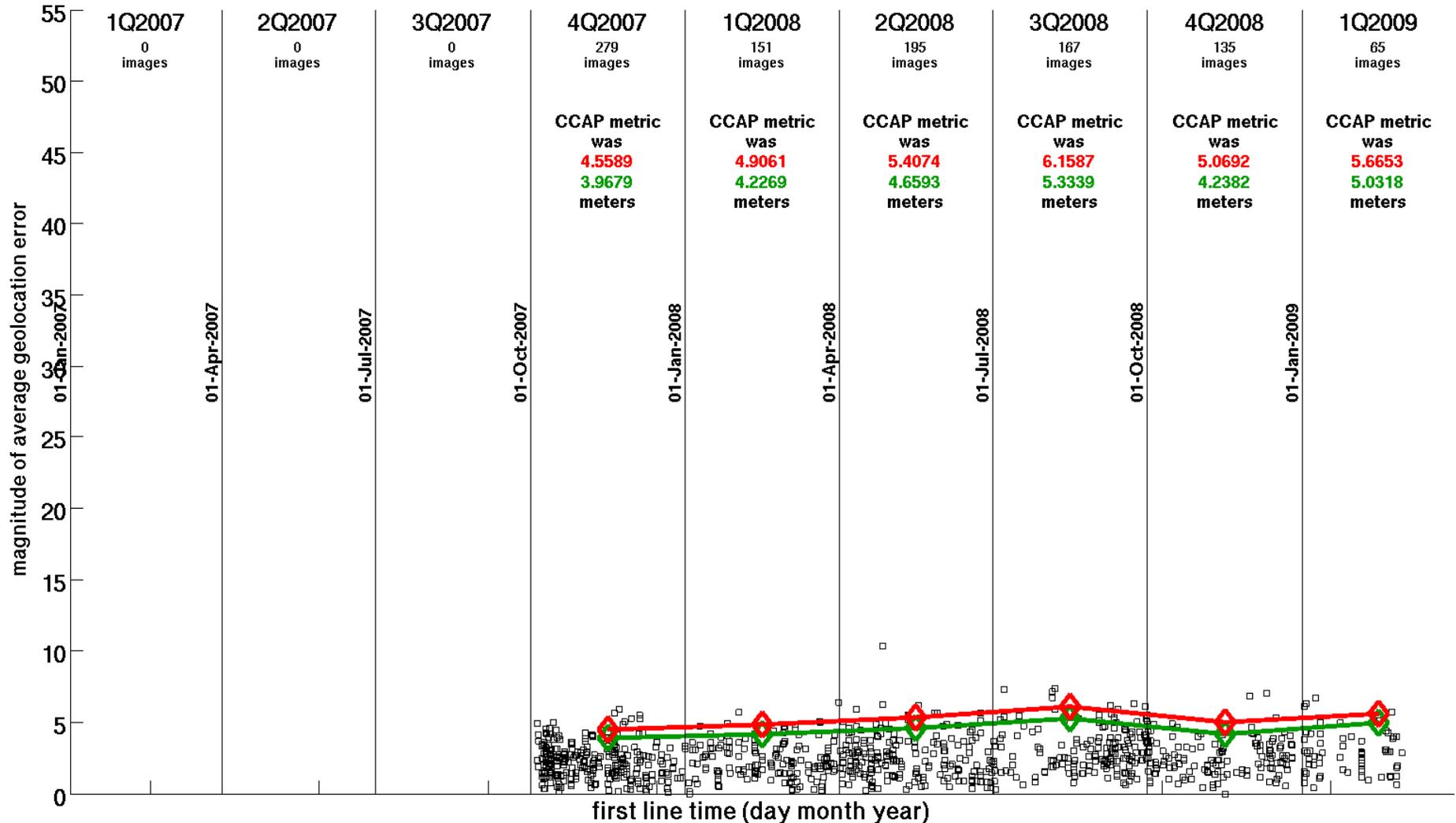




absolute geolocation accuracy by quarter

WV01

full errors
nadir projected errors

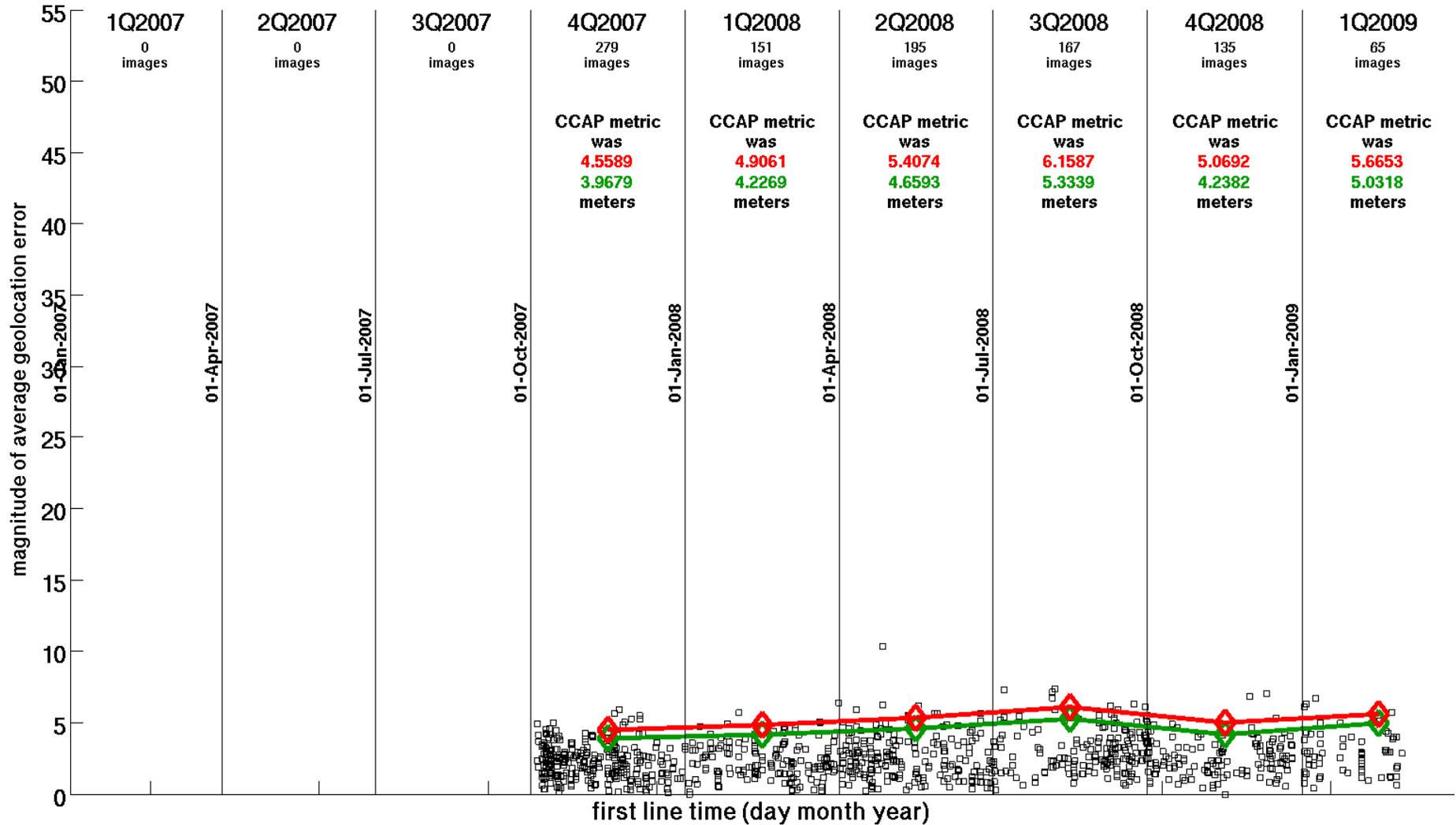




absolute geolocation flicker plot for emphasis

WV01

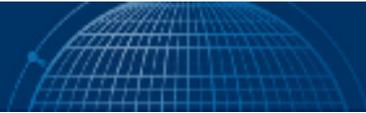
full errors
nadir projected errors



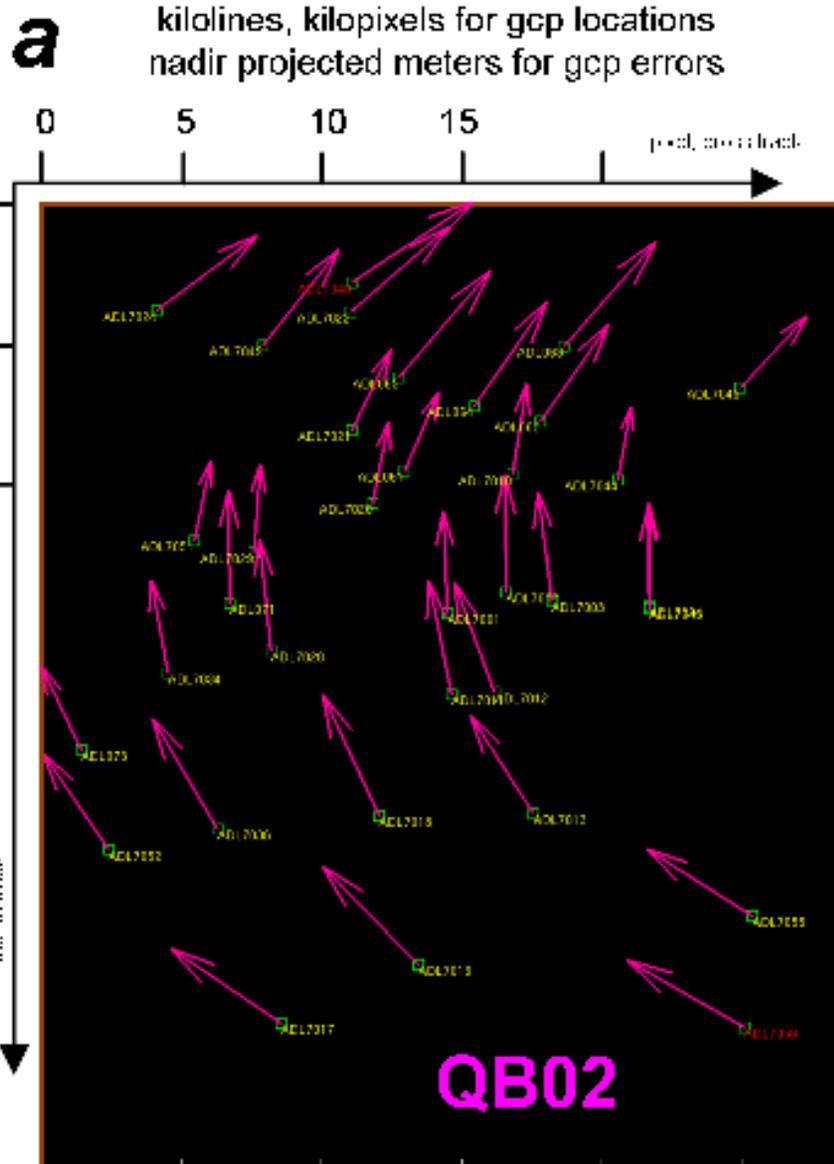
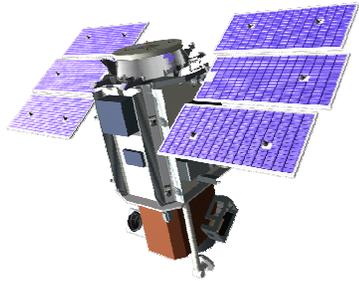


Relative Geolocation Accuracy

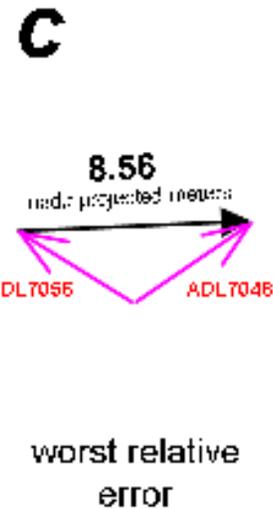
(using ordinary absolute accuracy data)

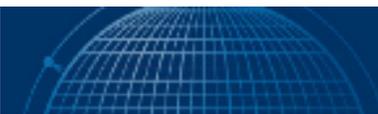


relative geolocation errors are made from vector differences

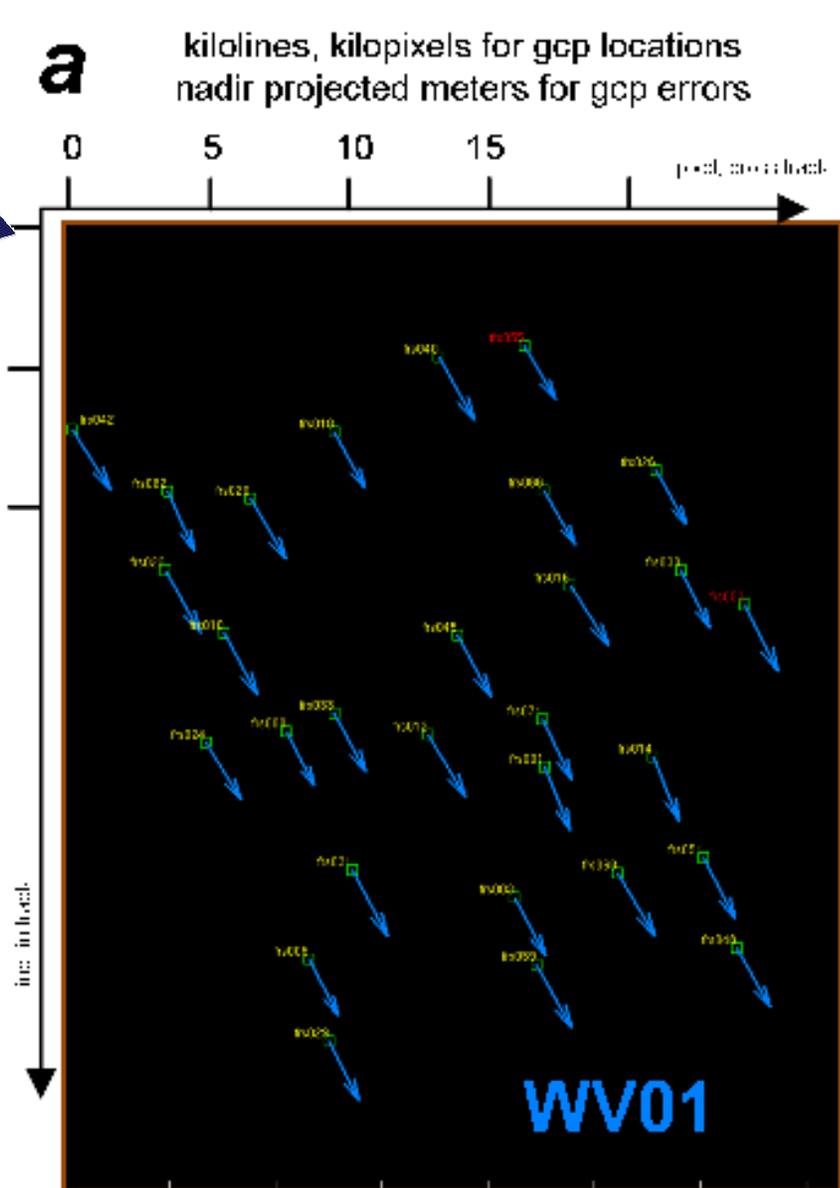


relative accuracy can be summarized by the **worst relative error**

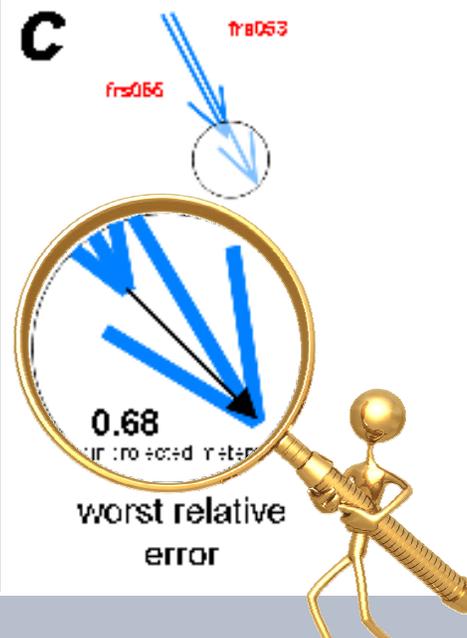




relative geolocation errors are made from vector differences



relative accuracy can be summarized by the **worst relative error**

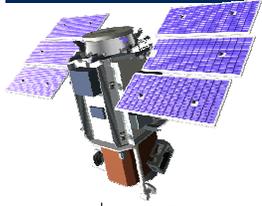


desired relative geolocation accuracy

no explicit goal... but let's just say

0 meters (projected to nadir) for **QB02**

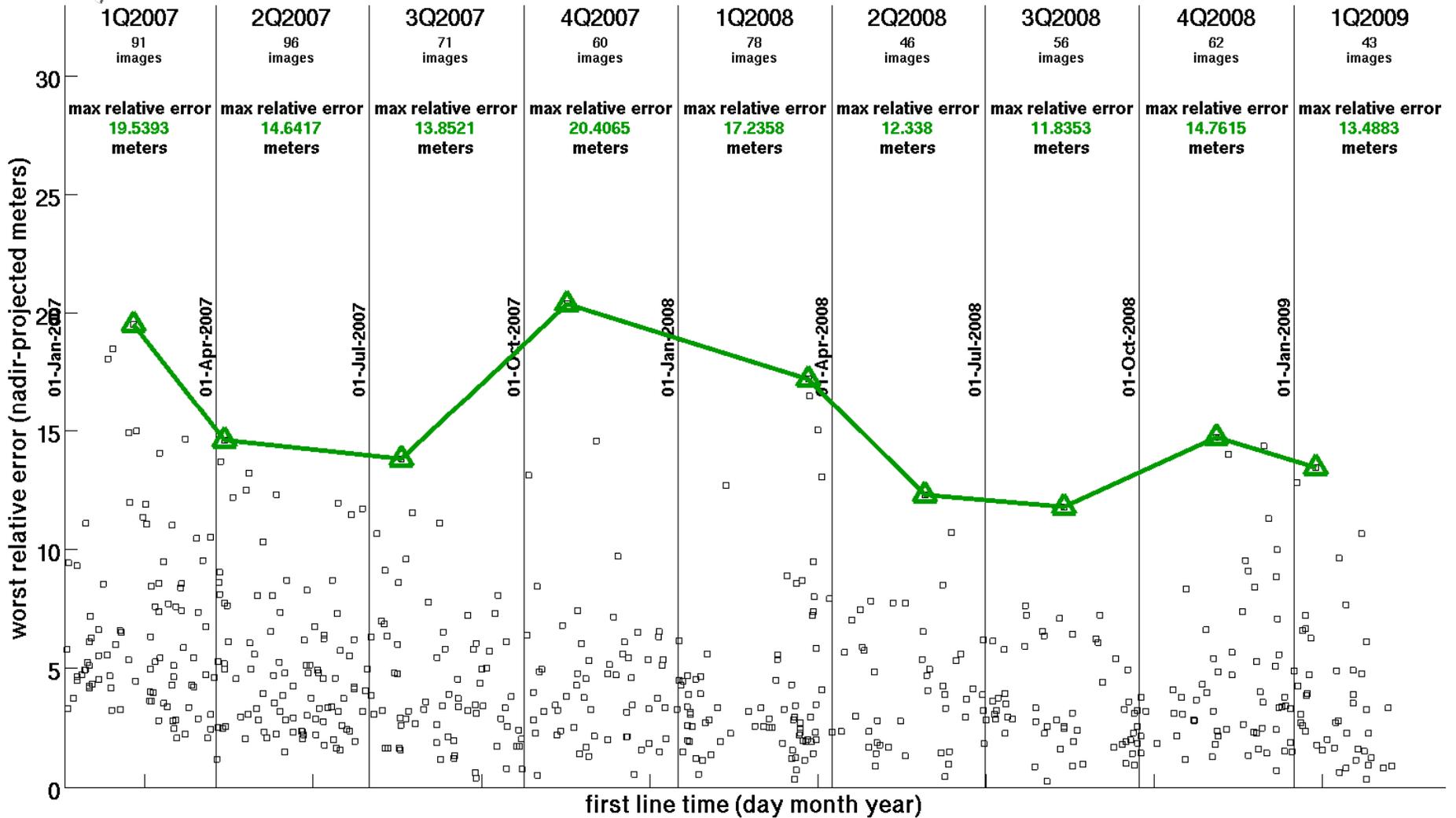
0 meters (projected to nadir) for **WV01**



relative geolocation accuracy by quarter

QB02

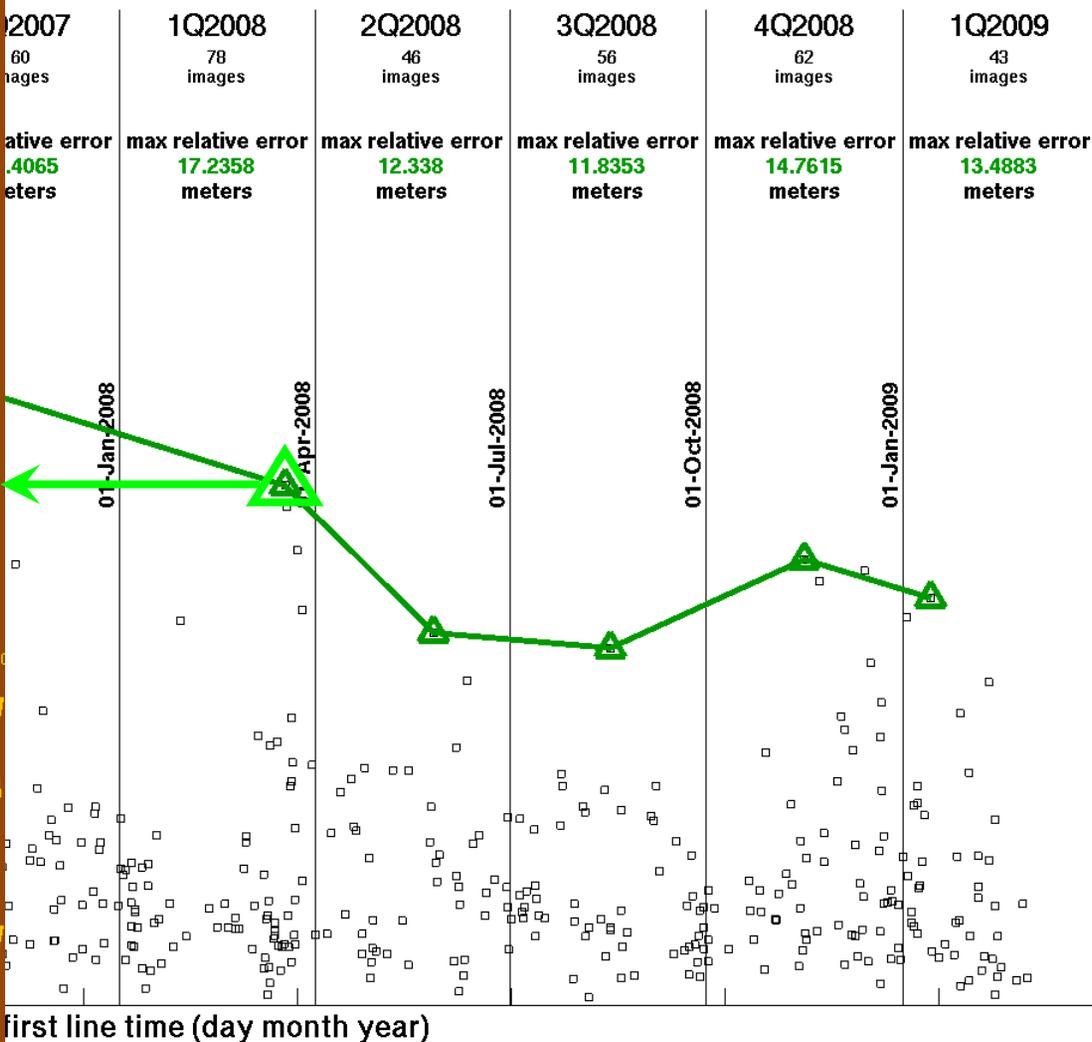
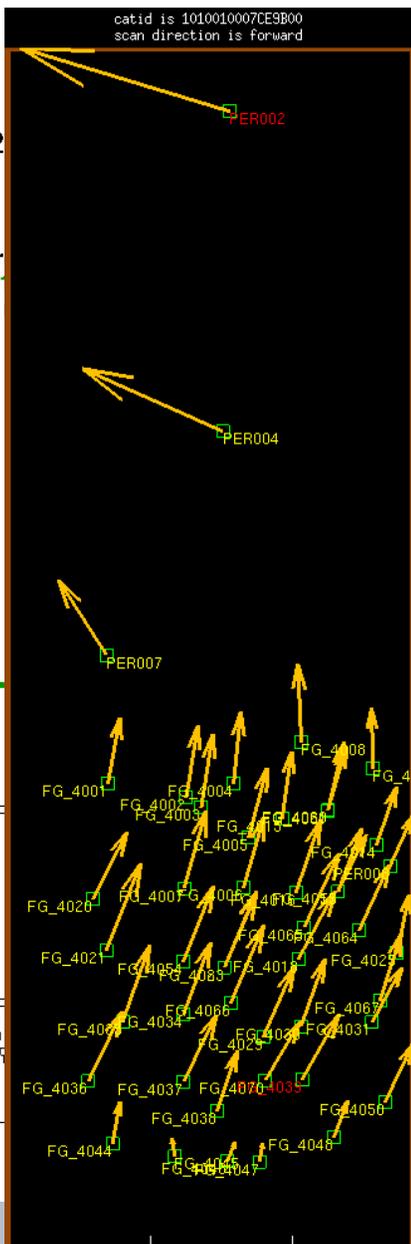
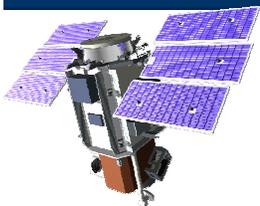
nadir projected errors

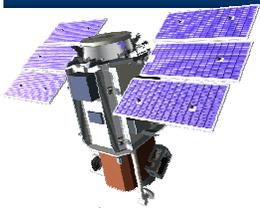
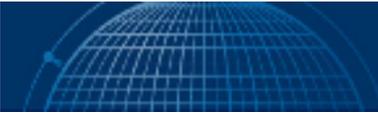


maxes can be spectacular swirls

QB02

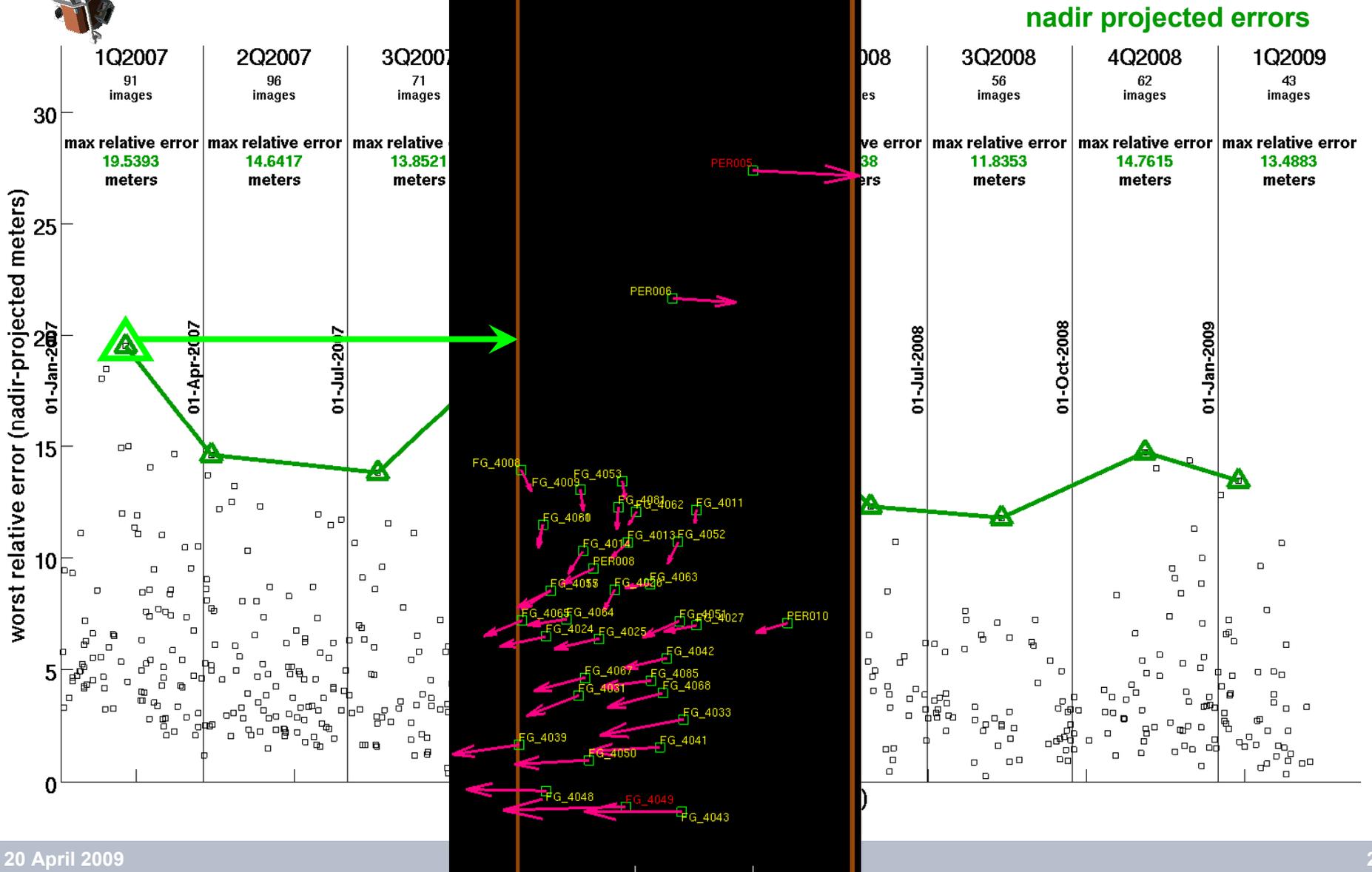
nadir projected errors

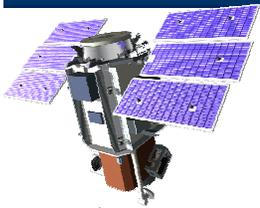




maxes can be spectacular swirls

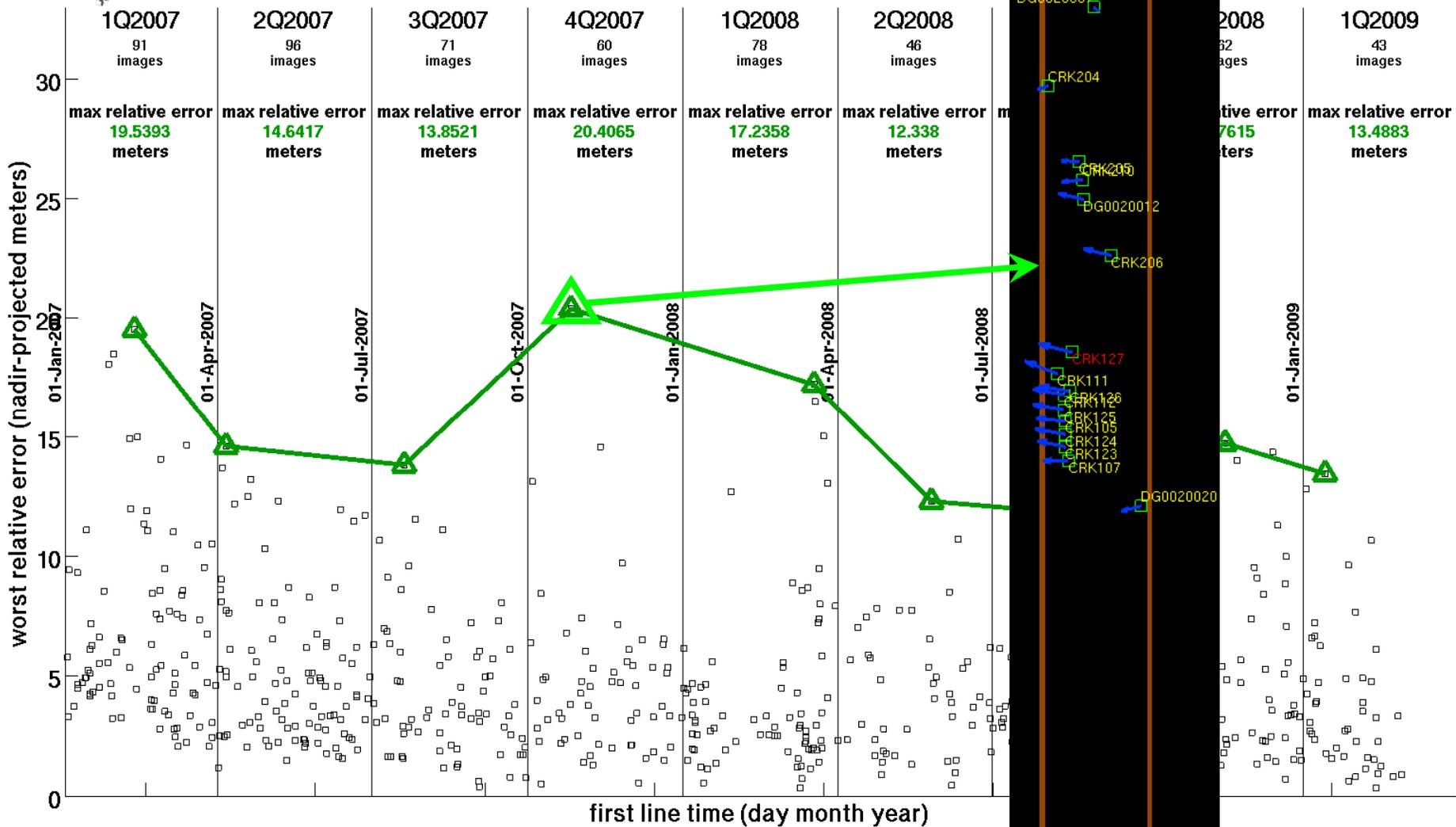
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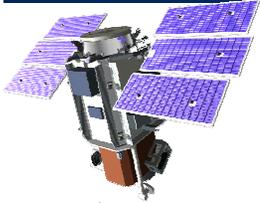




maxes can also be long strips QB02

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scan direction is forward

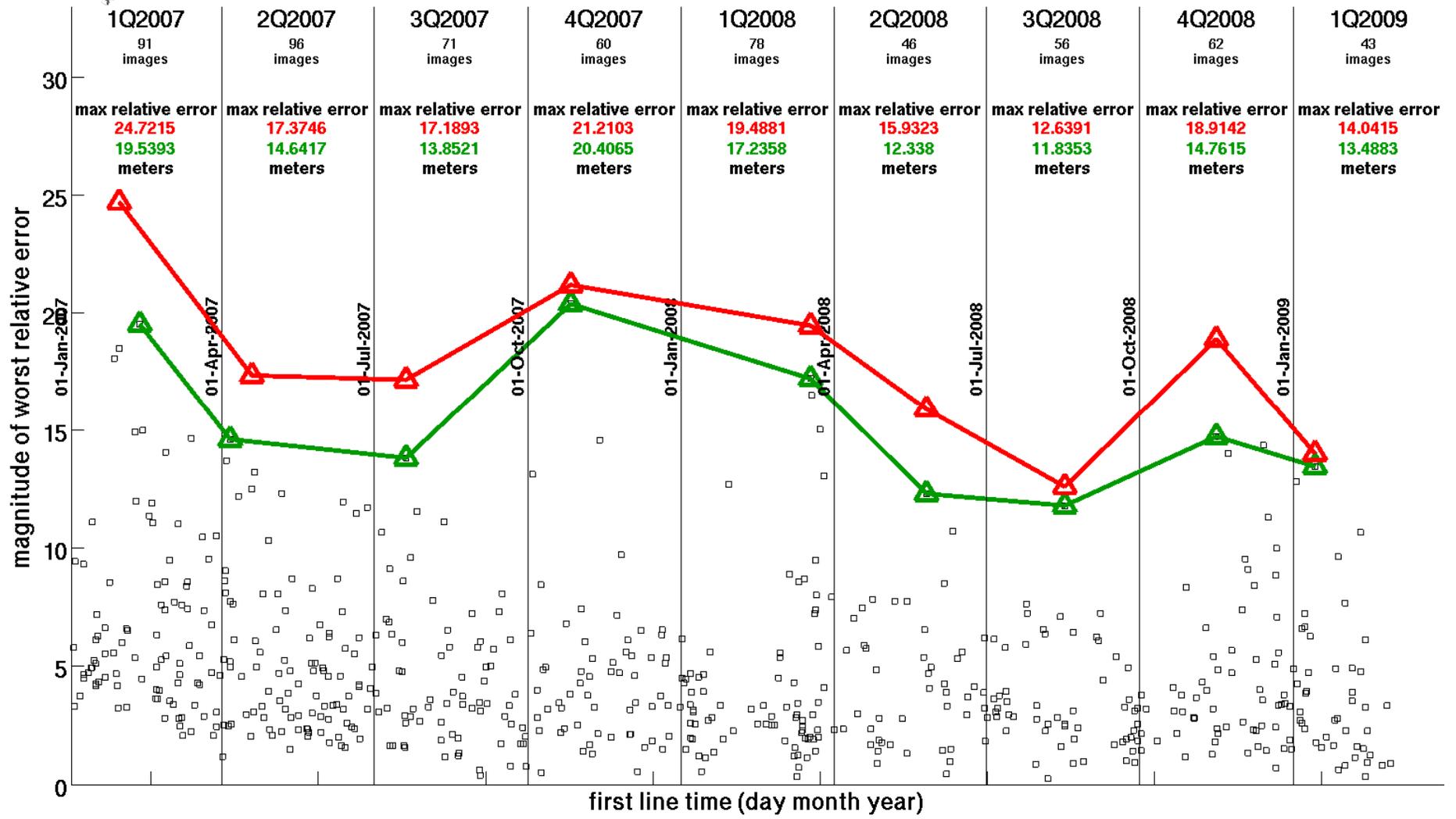




relative geolocation accuracy by quarter

QB02

full errors
nadir projected errors

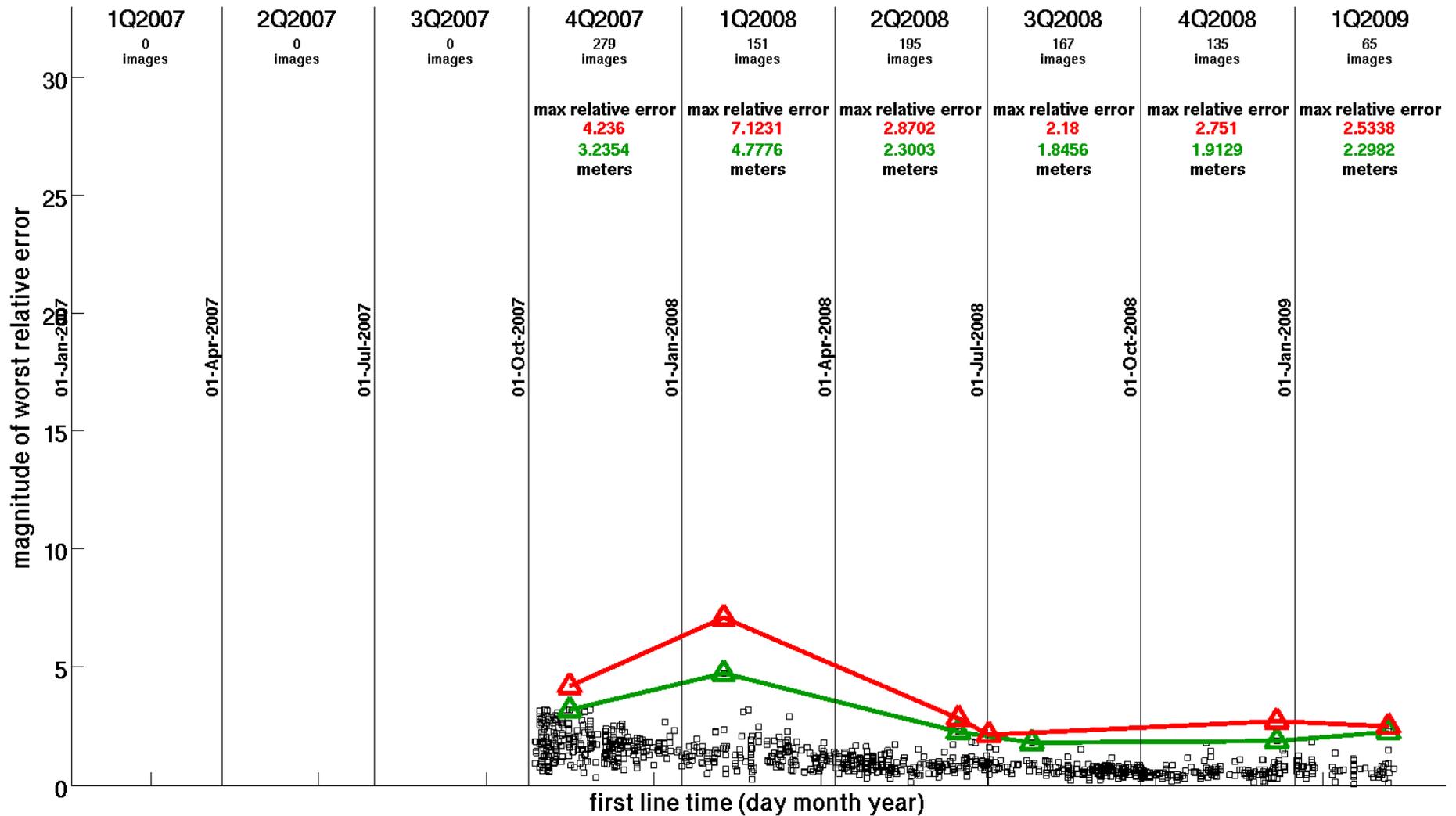




relative geolocation accuracy by quarter

WV01

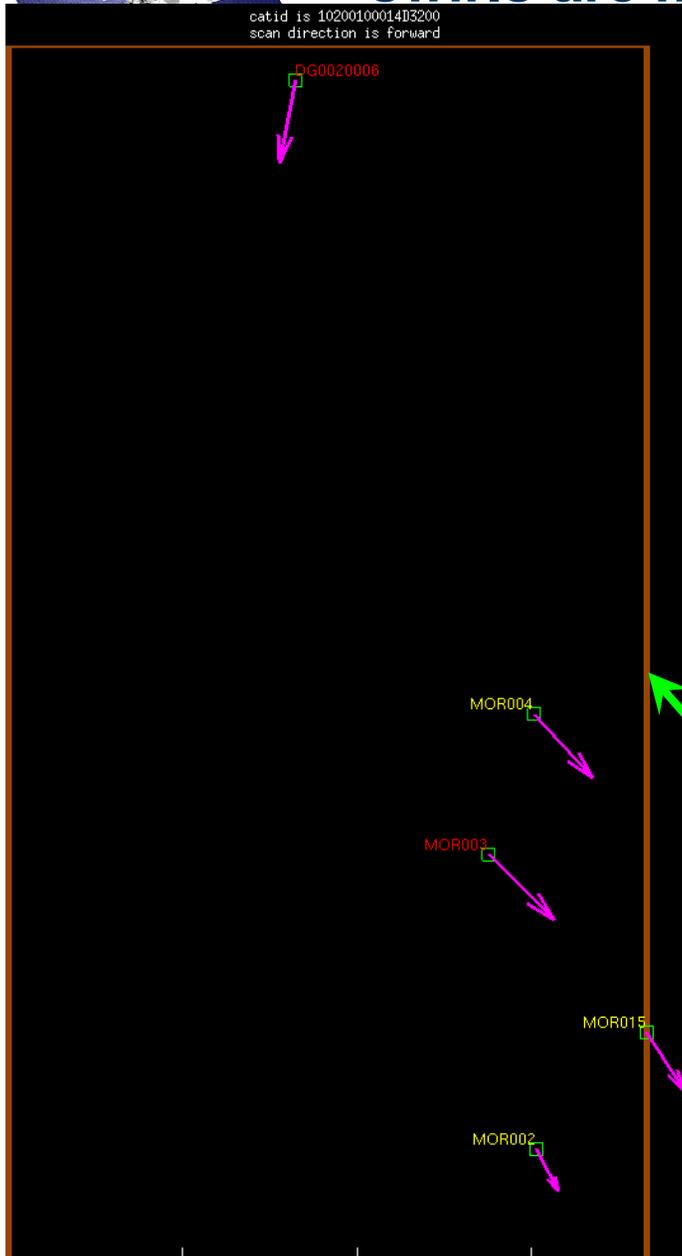
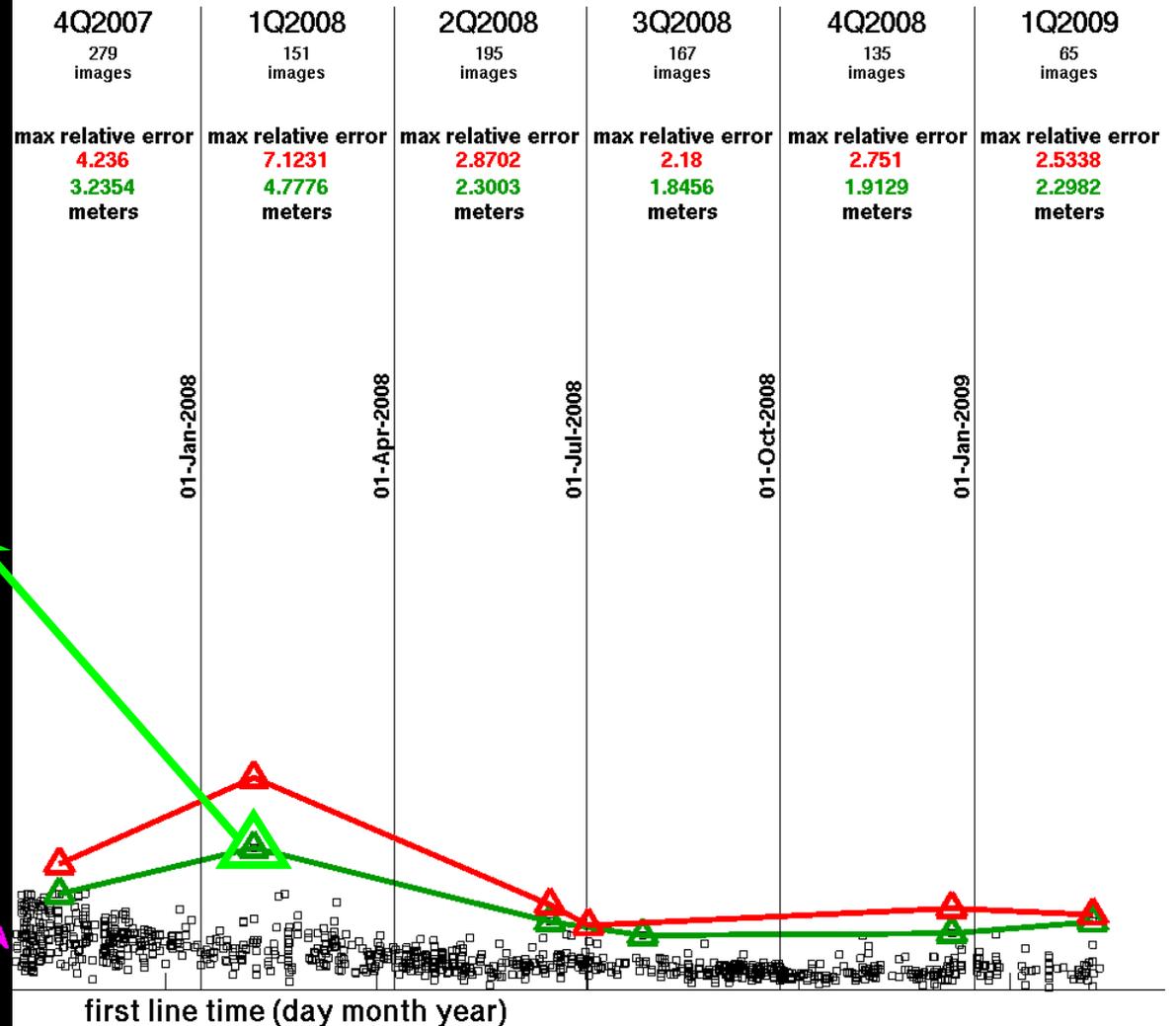
full errors
nadir projected errors

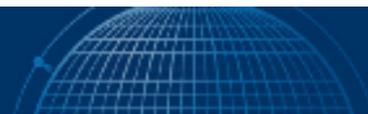


swirls are much less spectacular for WV01

WV01

full errors
nadir projected errors

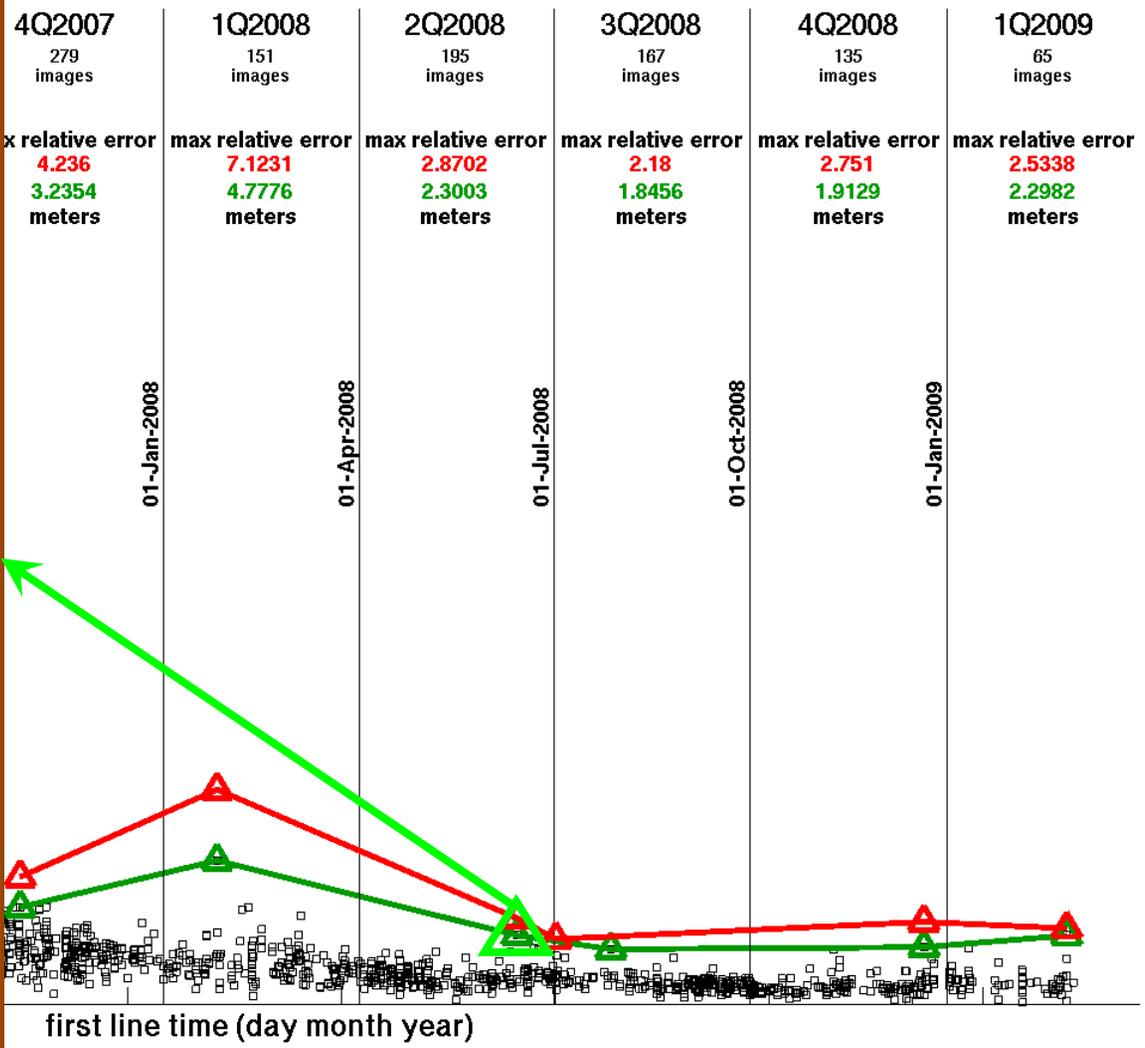
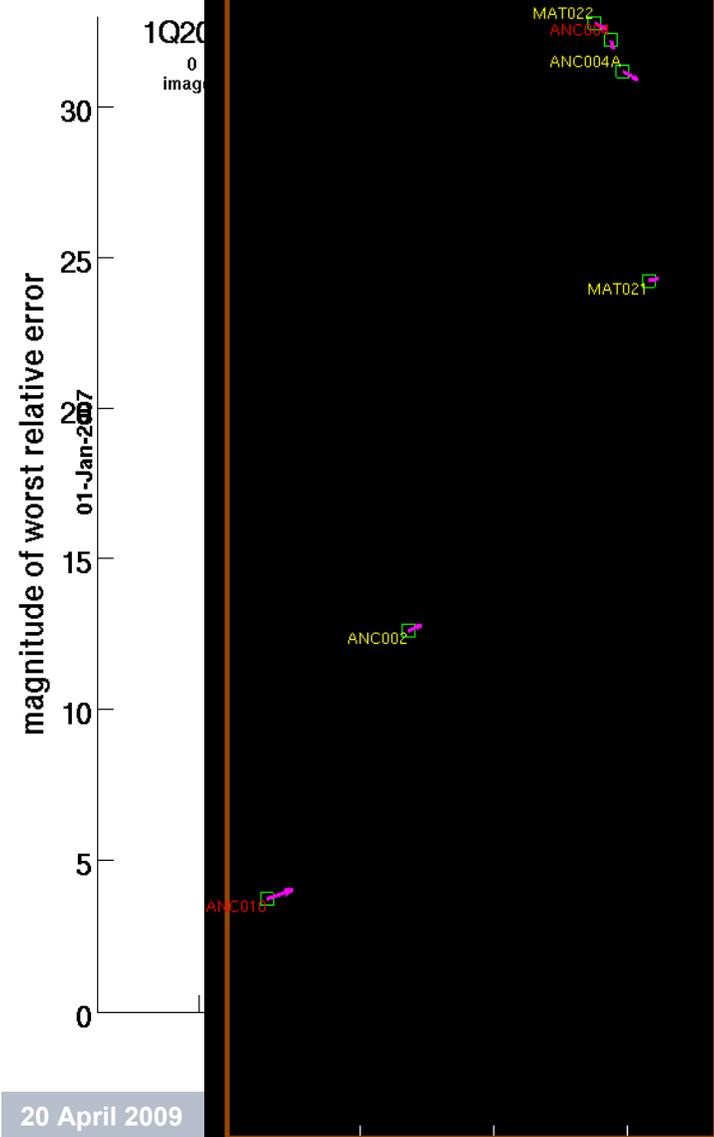




long strips also easier for WV01

WV01

full errors
nadir projected errors

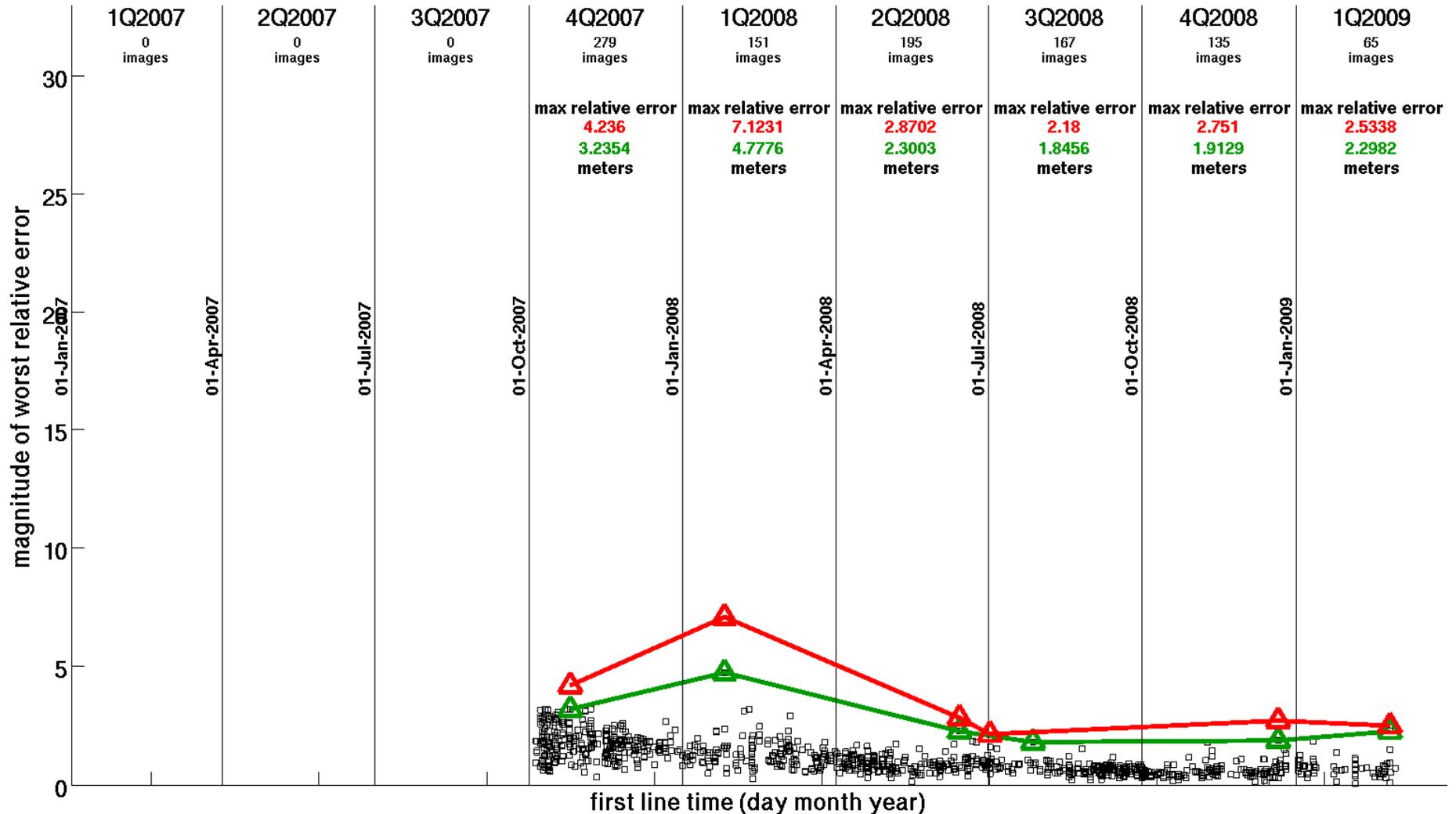


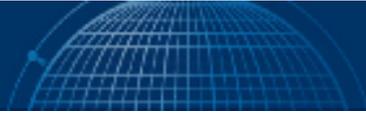


flicker plot of ordinary relative accuracy

WV01

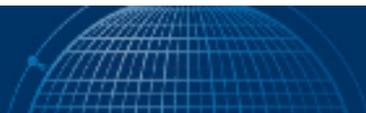
full errors
nadir projected errors



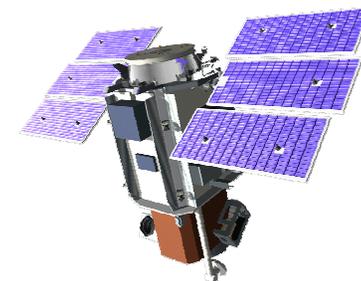
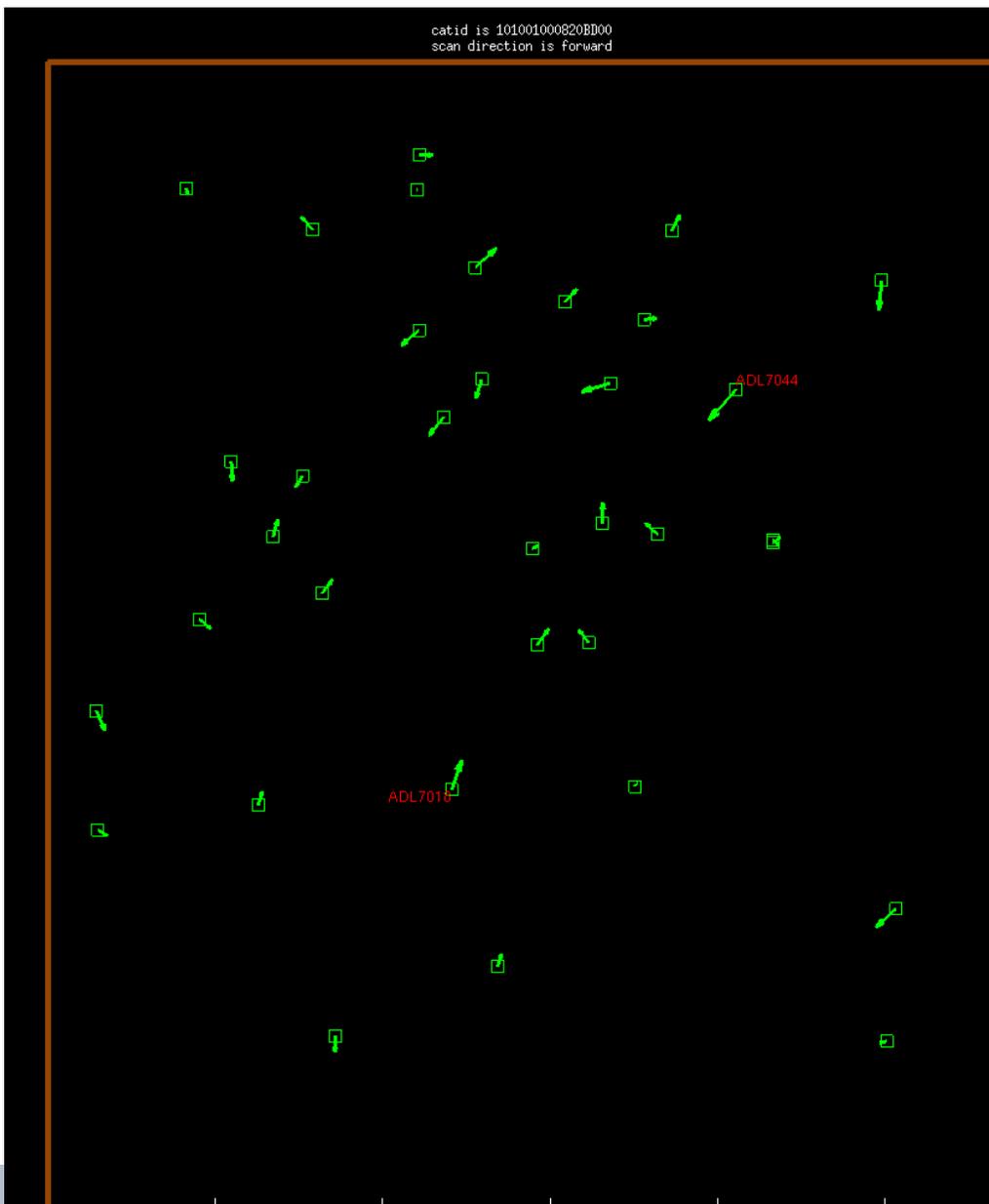


Relative Geolocation Accuracy

(using detrended absolute accuracy data)



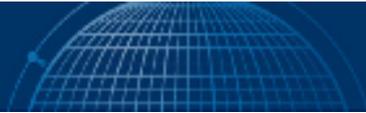
absolute geolocation errors can be detrended



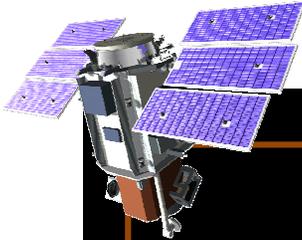
detrending

is a least squares fit to find attitude offsets that minimize absolute geolocation error:

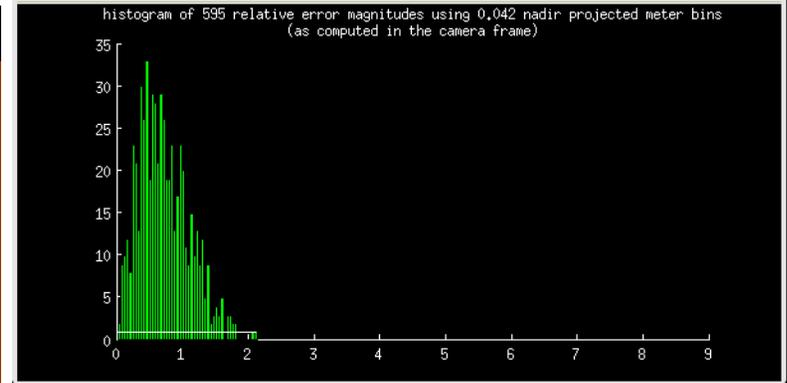
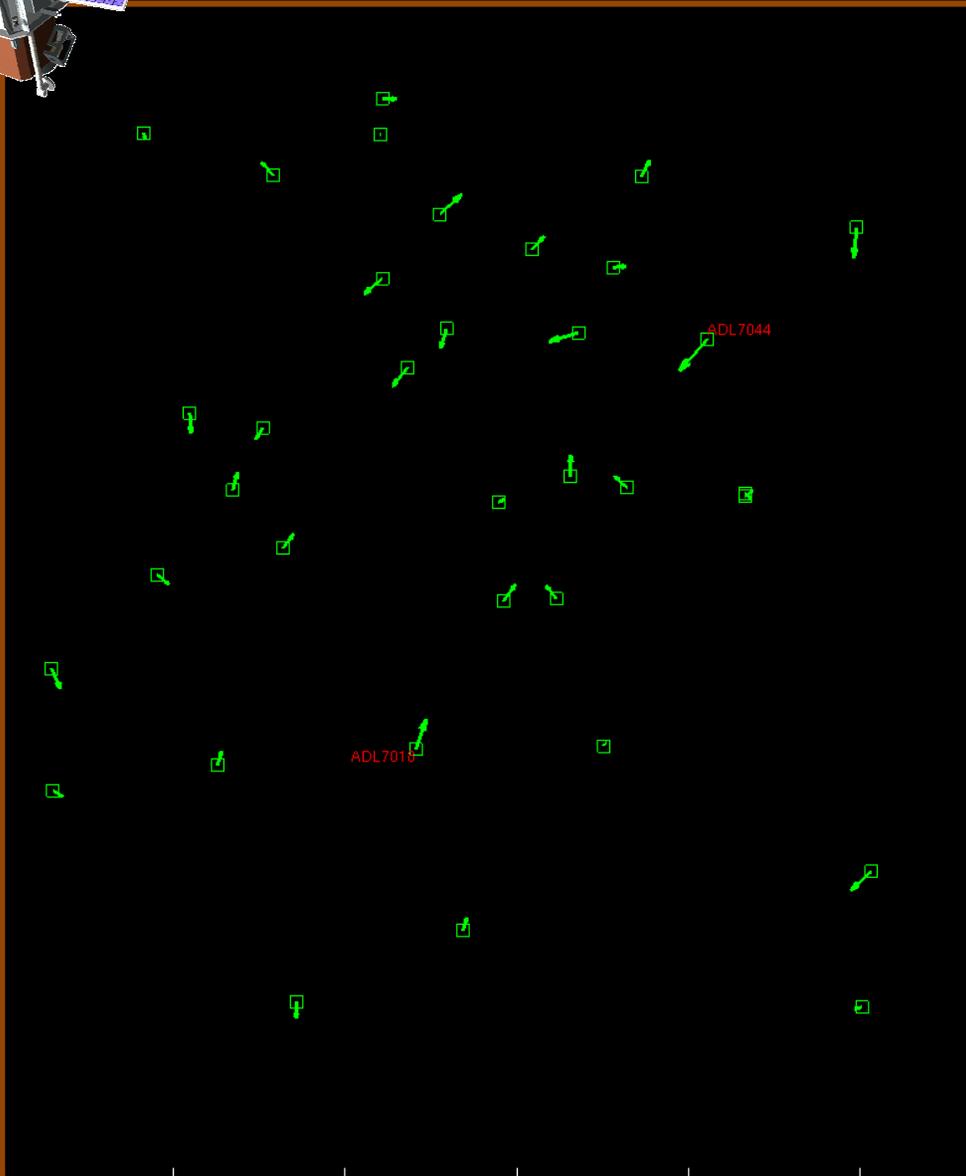
	bias (μ r)	rate (μ r/s)	accel (μ r/s/s)
roll	15.8	-7.1	0.4
pitch	-5.0	-2.2	0.4
yaw	-39.9	-1.0	4.9



absolute geolocation errors can be detrended

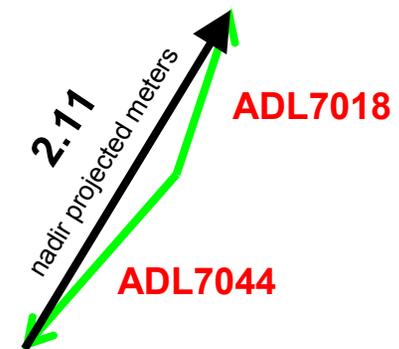


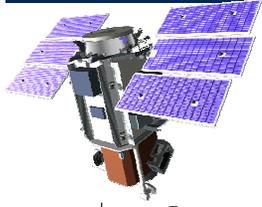
catid is 101001000820BD00
scan direction is forward



relative accuracy can be
recalculated for each geocal strip
using the **detrended** absolute
errors

worst relative error

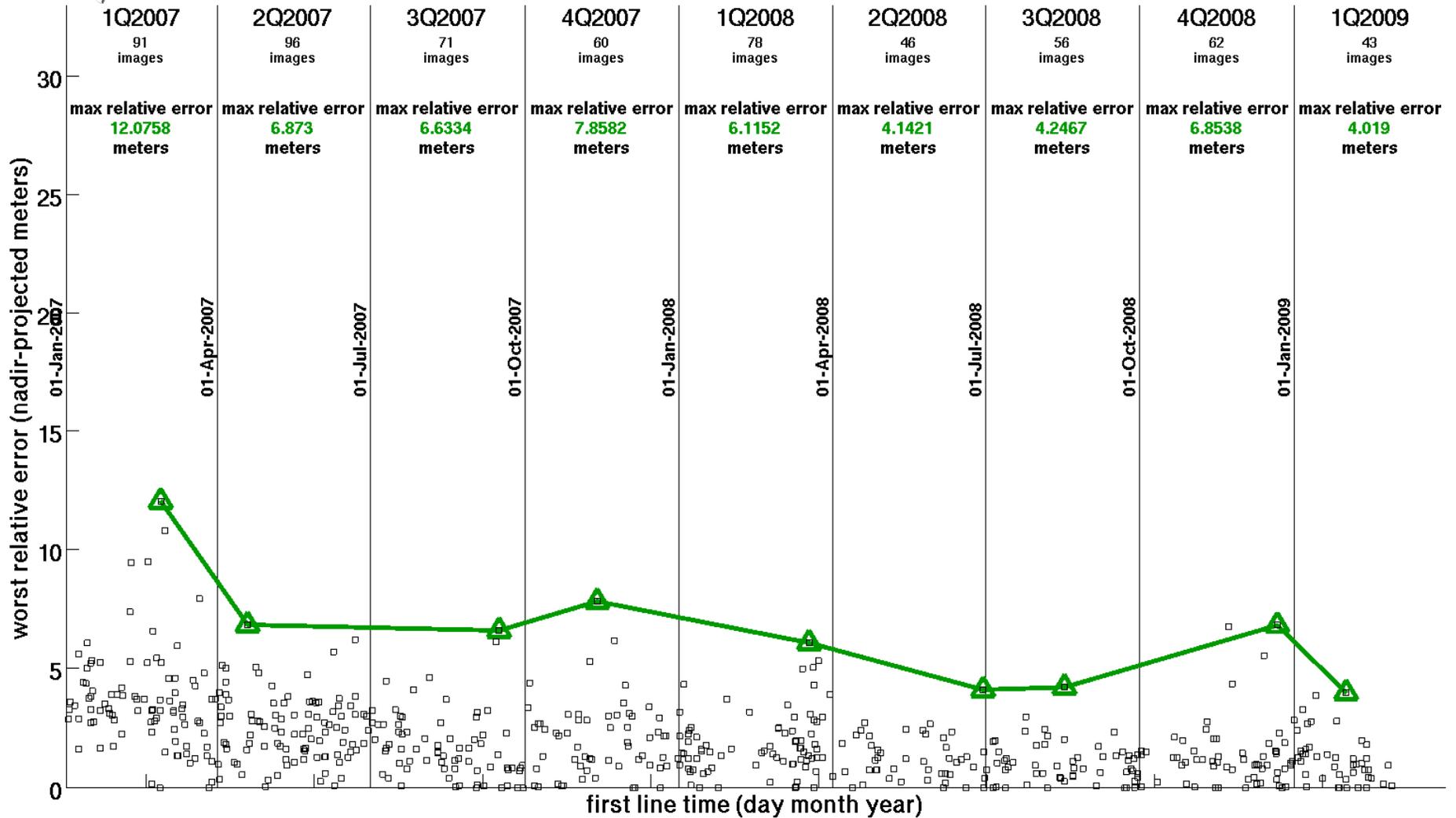




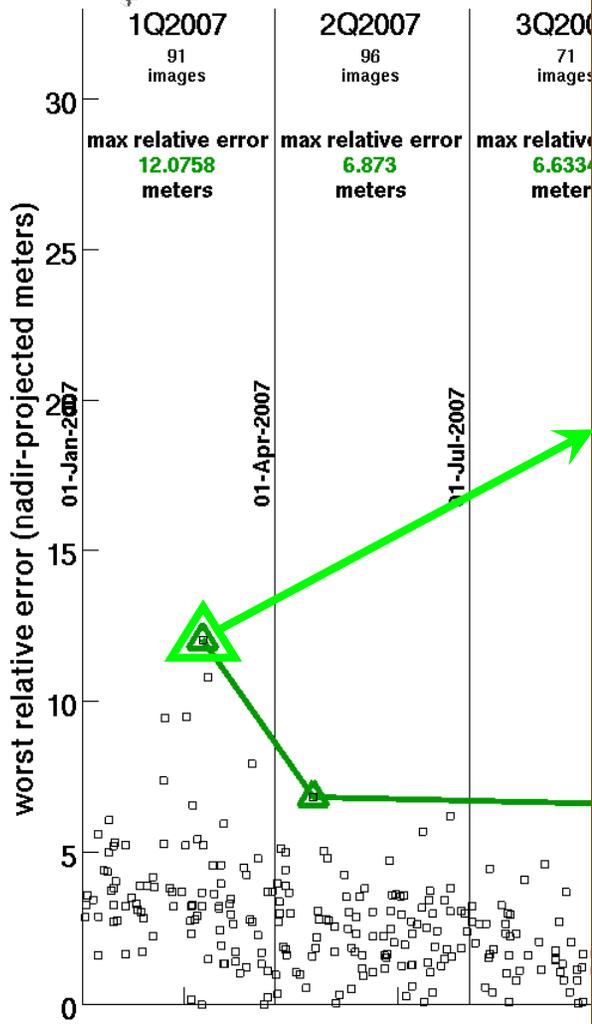
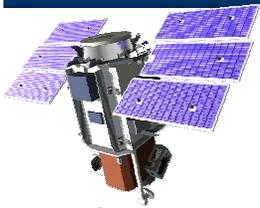
worst relative errors using detrended data

QB02

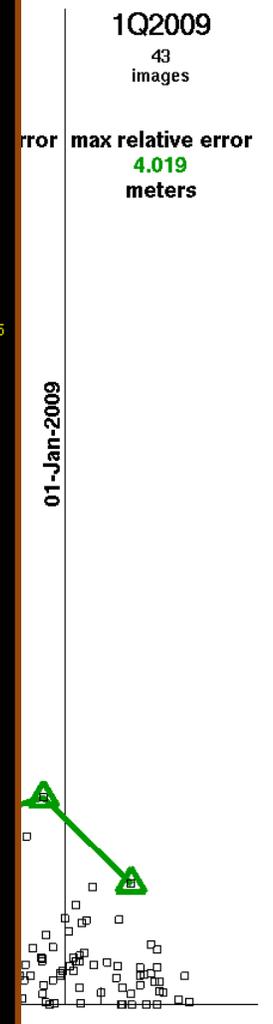
nadir projected errors

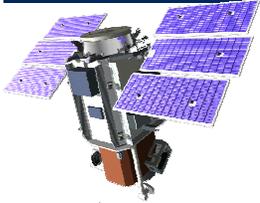


detrended maxes can be bad gcp clicks

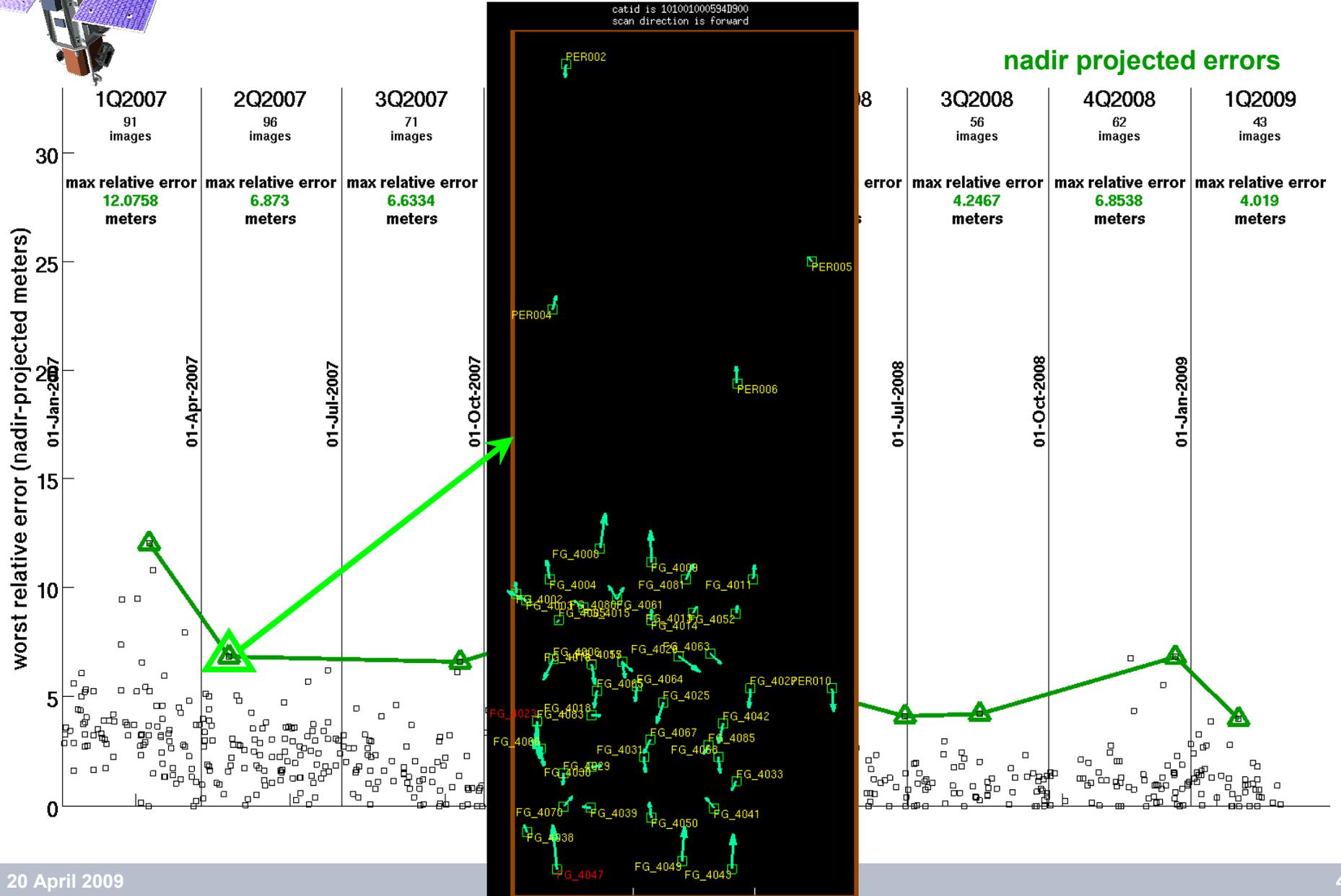


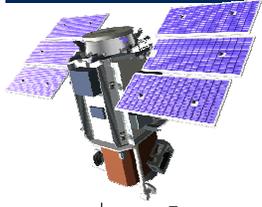
ted errors





detrended maxes are also long, complicated strips

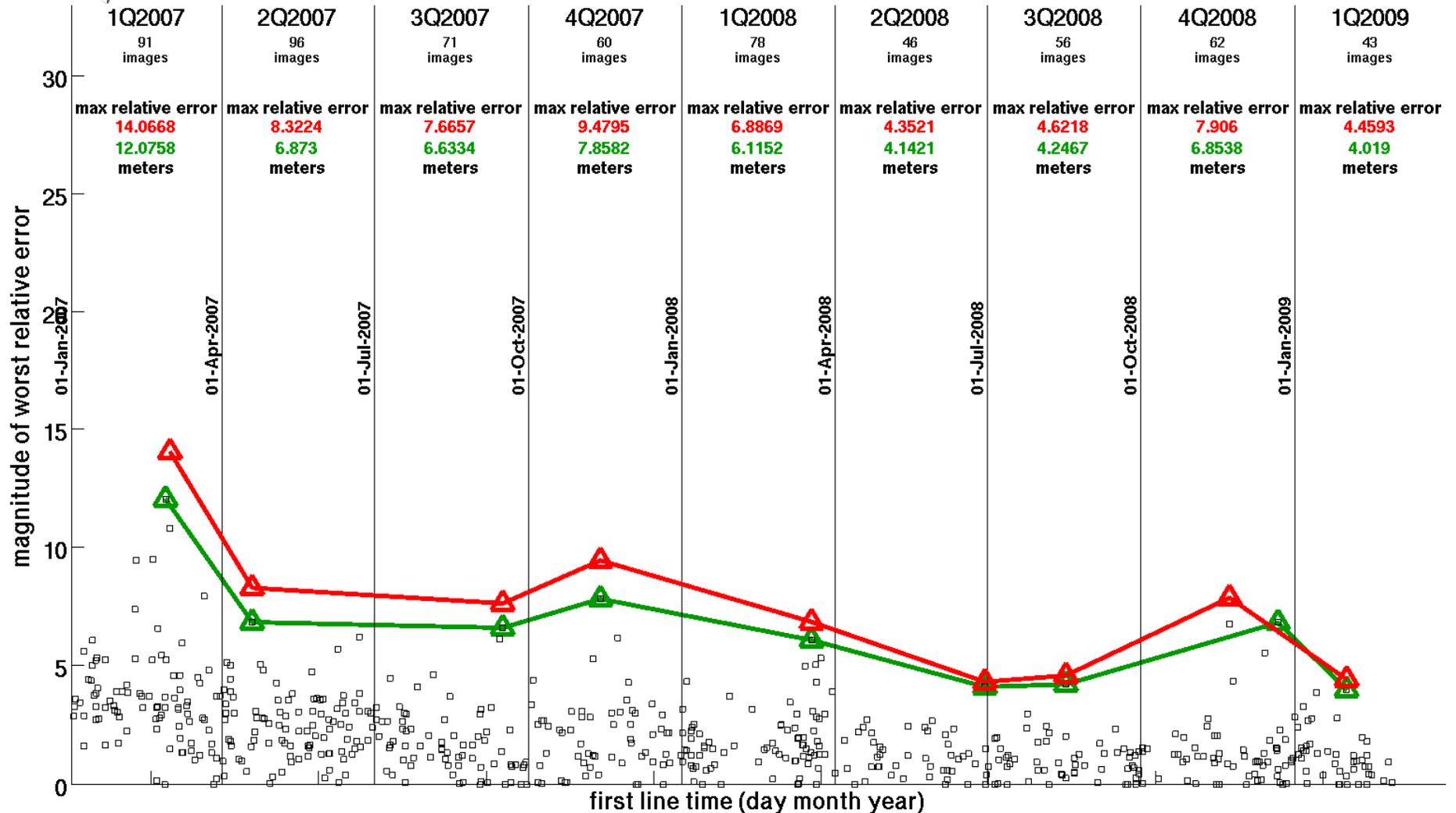




worst relative errors using detrended data

QB02

full errors
nadir projected errors

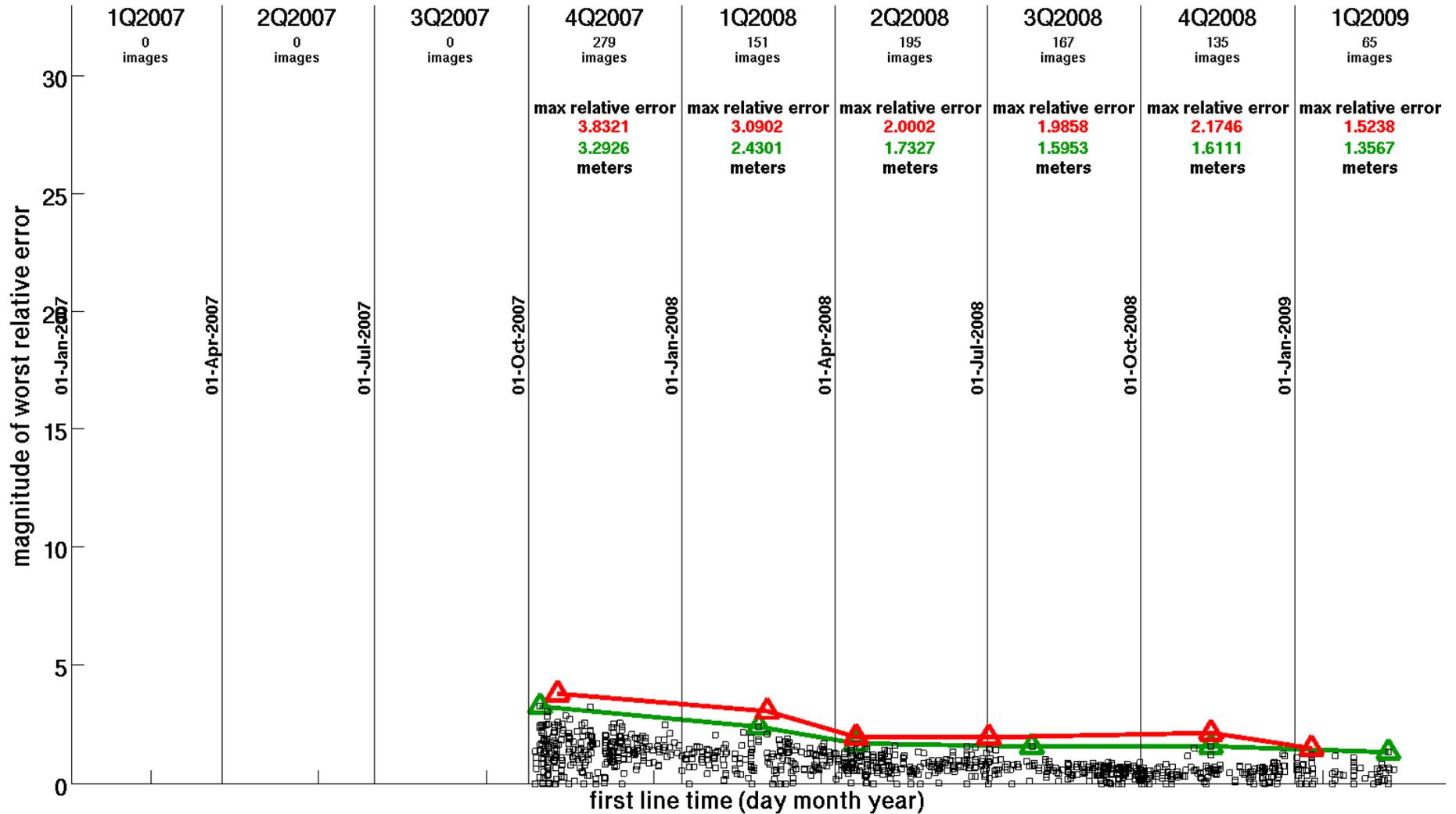




worst relative errors using detrended data

WV01

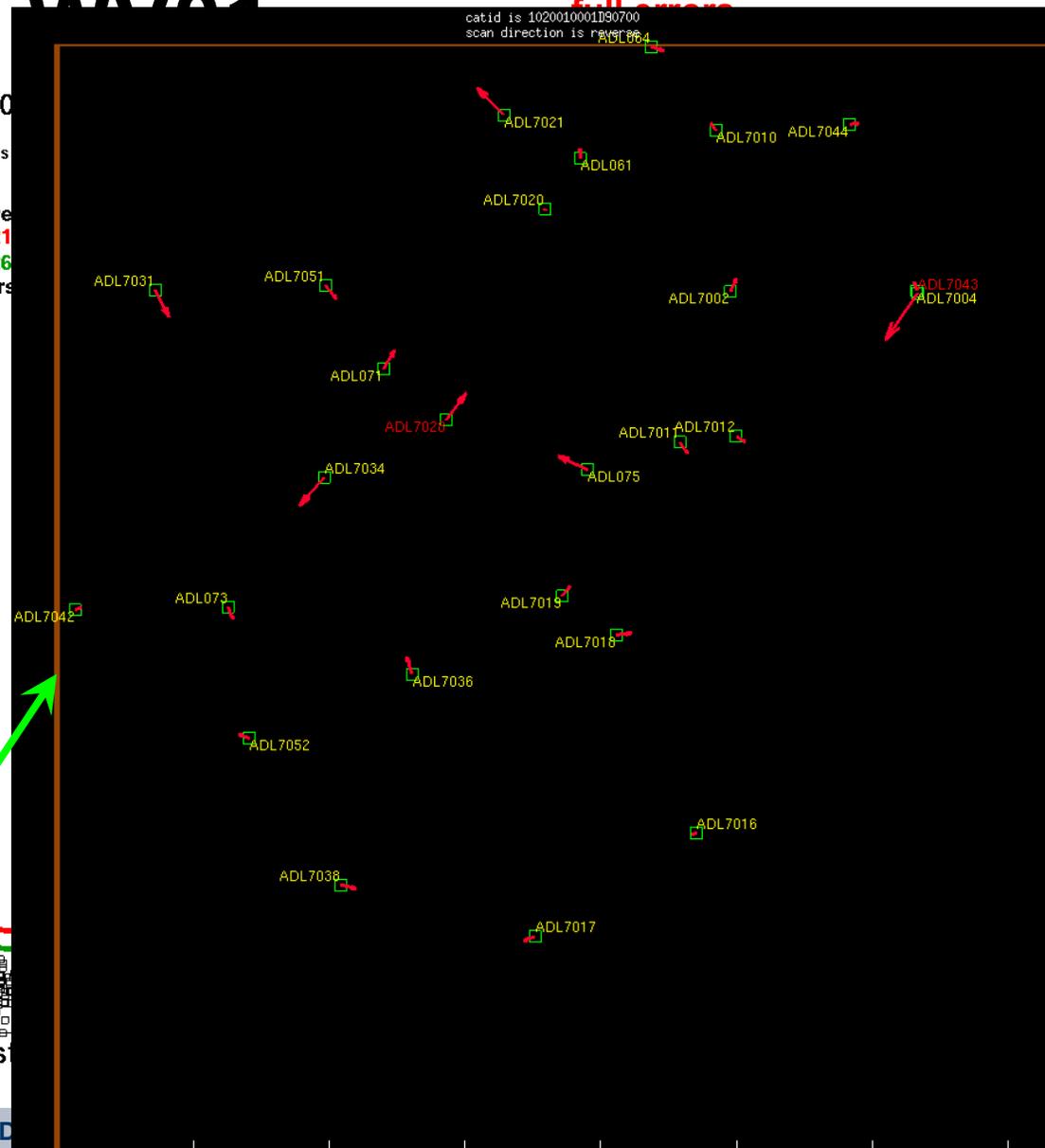
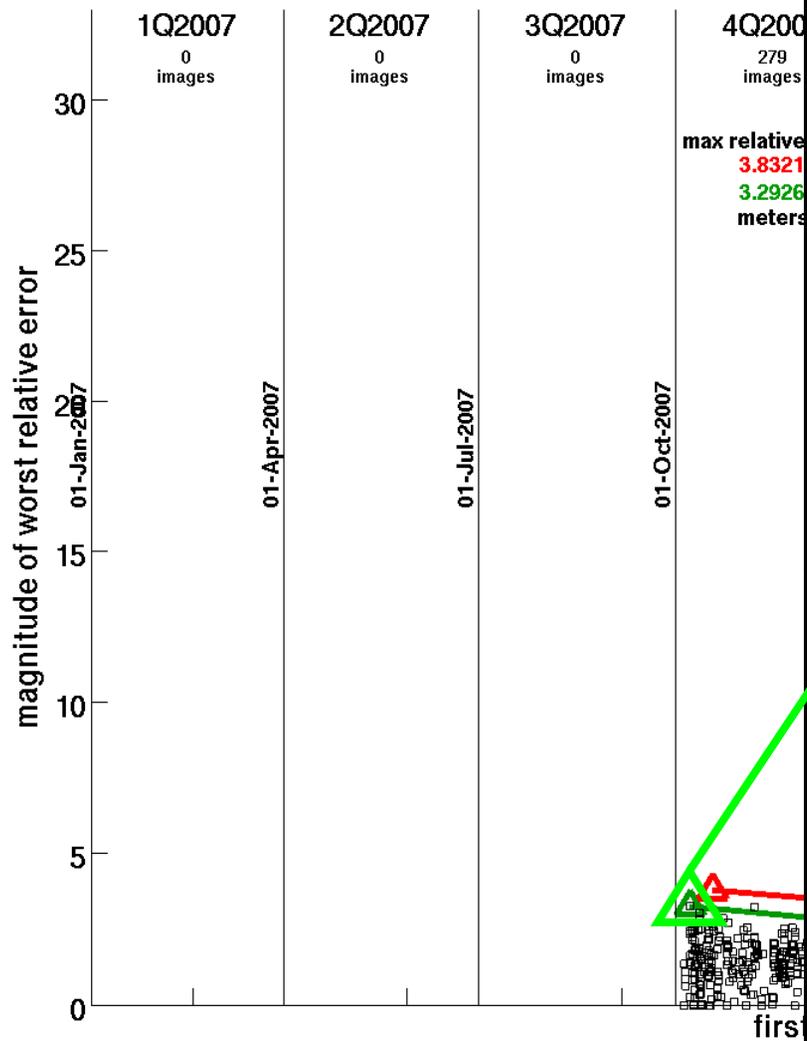
full errors
nadir projected errors





bad gcp clicks for WV01 have less impact

WV01

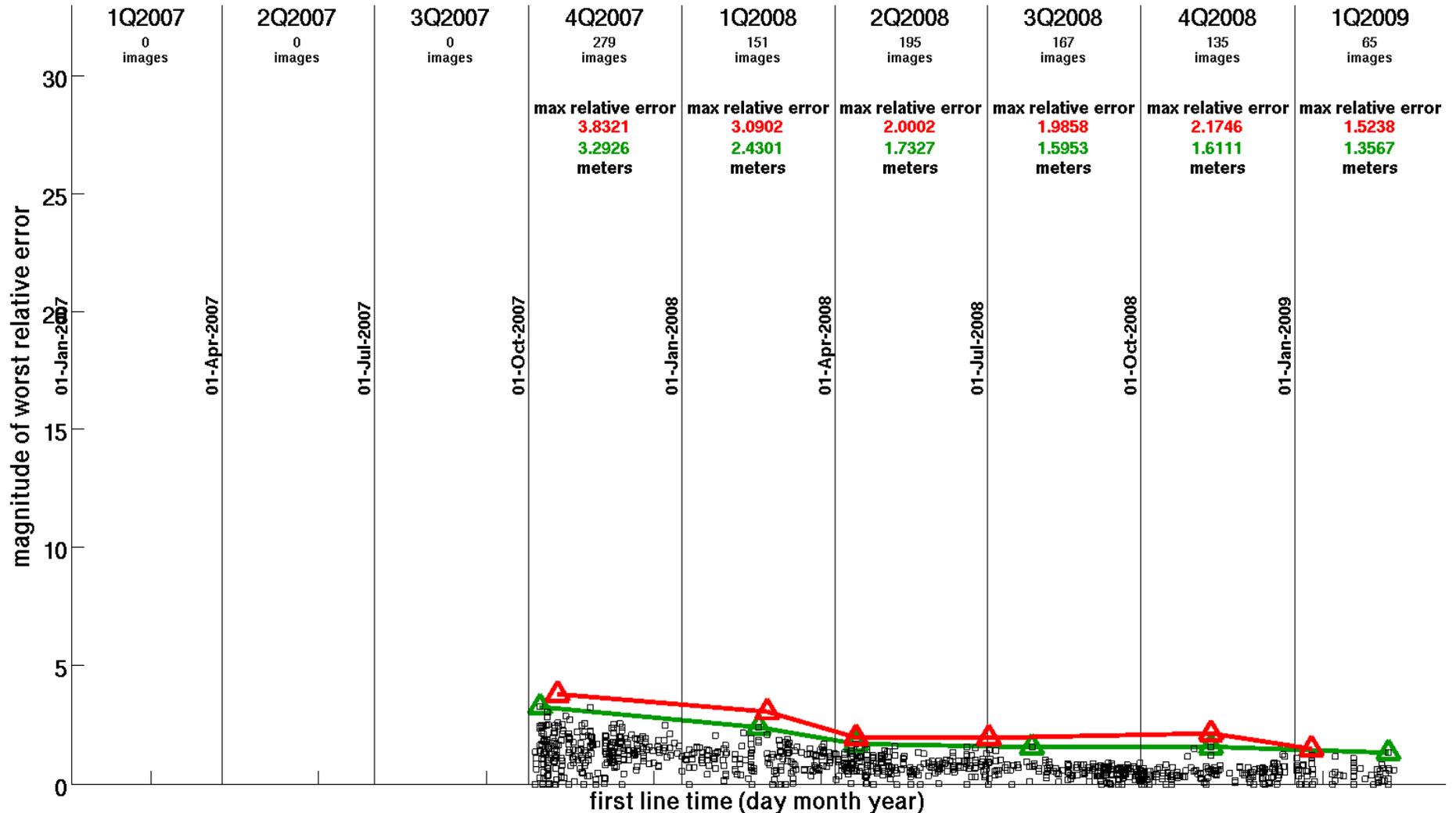




flicker plot of detrended relative accuracy

WV01

full errors
nadir projected errors





conclusions



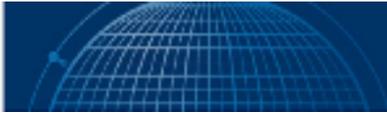
conclusions

Both QB02 and WV01 meet their respective goals for **absolute geolocation accuracy**:

- recall desired absolute accuracy
 - **QB02: 23 meters** projected to nadir
 - **WV01: 6.5 meters** projected to nadir

- over last two years, when binned into quarters, each quarterly CCAP metric (90th percentile) meets goal. Each satellite has characteristic spread:
 - **QB02: 14.1 to 20.8 meters** projected to nadir
 - **WV01: 4.0 to 5.3 meters** projected to nadir

quarterly absolute geolocation accuracy summary		
	min	max
QB02	14.1	20.8
WV01	4.0	5.3



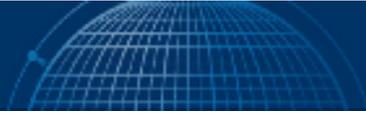
conclusions

We have no goal for **relative geolocation accuracy**, but there are plenty of great results:

- using ordinary absolute geolocation data in quarterly bins, max relative error fluctuates between
 - **QB02: 11.8 to 20.4 meters** projected to nadir
 - **WV01: 1.8 to 4.8 meters** projected to nadir
 - maxes were spectacular swirls and long strips

- using **detrended** absolute geolocation data in quarterly bins, max relative error fluctuates between
 - **QB02: 4.0 to 12.0 meters** projected to nadir
 - **WV01: 1.4 to 3.3 meters** projected to nadir
 - maxes were gcp misclicks and long strips too complex to fit well with simple biases, rates, etc...

quarterly relative geolocation accuracy summary				
	ordinary		detrended	
	min	max	min	max
QB02	11.8	20.4	4.0	12.0
WV01	1.8	4.8	1.4	3.3



questions?