

# QuickBird-2 Geolocation Accuracy Assessments from 2005 and 2006

*Dr. Byron Smiley*  
DigitalGlobe



## Outline

**This will be about improvements to QB02 geolocation in 2006**

- **geolocation accuracy assessment at DigitalGlobe**
- **old QB02 geocal stats from 2005**
- **new attitude files, adp40, in 2006**
- **new QB02 geocal stats for 2006**
- **expected improvement in geolocation vs. reality**
- × **no aerial geolocation data**



## Geolocation Assessment at DigitalGlobe

- **Two departments actively collect geolocation statistics**
  - **Quality Control / Quality Assurance**
    - random sampling of whatever is passing through
    - daily checks, weekly reports, internal to DG
  - **Remote Sensing Sciences (Byron, the Geometric Calibration Engineer)**
    - systematic sampling of 18 sites (next slide)
    - monthly checks, quarterly reports, externally distributed to NGA, JACIE...
- **One source of passively collected geolocation statistics**
  - named “the Reporter”
  - “Byron’s spyware”, embedded in Product Processor
  - passively records geolocation errors for a strip when making an ortho, errors would have been discarded
  - irregular sampling, irregular reports
  - started ~Jul 2006, so not enough data for discussion today





## Geocal Sites

**Remote Sensing Sciences uses a suite of 18 cities for monthly geolocation checks**

1. Adelaide, Australia
2. Anchorage, Alaska
3. Cape Town, South Africa
4. Castle Rock, Colorado
5. Dubai, United Arab Emirates
6. El Paso, Texas
7. Fairbanks, Alaska
8. Fresno, California
9. Karachi, Pakistan
10. Las Vegas, Nevada
11. Lima, Peru
12. Longmont, Colorado
13. Morrison, Colorado
14. Perth, Australia
15. Phoenix, Arizona
16. Port Hedland, Australia
17. Salalah, Oman
18. Spokane, Washington

**Each has from 15 to 100 GCPs**



# Geocal Conventions

The horizontal error is found, but converted to the **nadir-projected error**.



450 km

**Why?**  
*Strips with different nadir angles need meaningful comparison.  
The camera coordinate system is advantageous:  
the same camera took every strip  
camera angles can be directly compared*

geocal imagery collected at off nadir angles between 0 to 30°

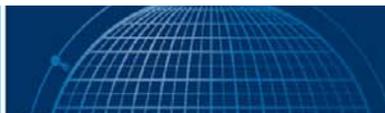
true GCP location

projected GCP location

nadir projected error

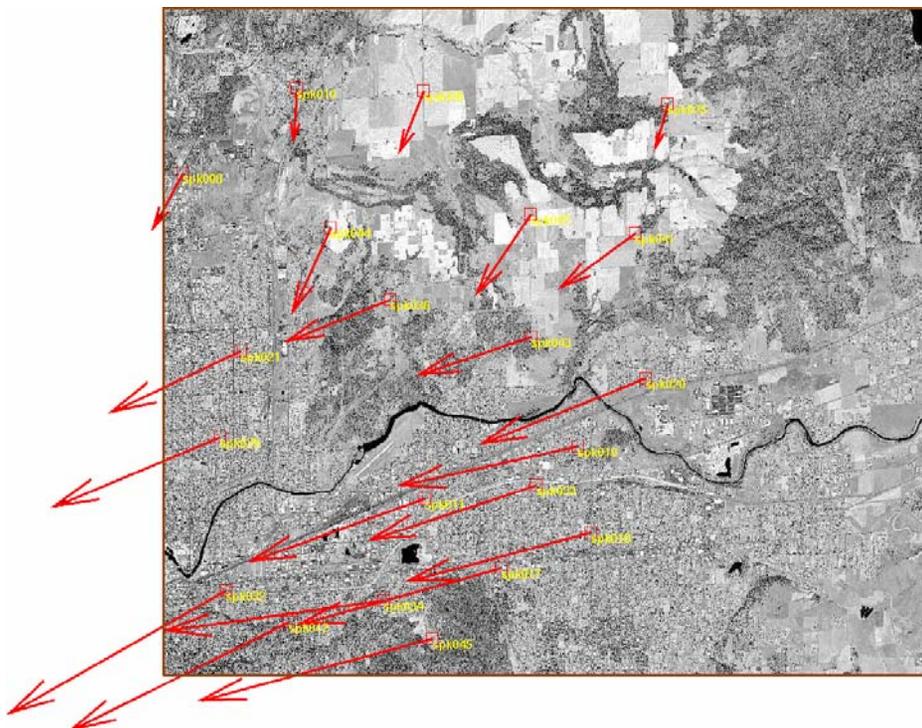
horizontal error\* = truth - measured

\* vertical error made zero by projecting to same height above ellipsoid as GCP



## CE90 of a QB02 Strip

DigitalGlobe takes the 90<sup>th</sup> percentile of the nadir-projected magnitudes



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

$$N * 0.9 = i + f$$

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

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

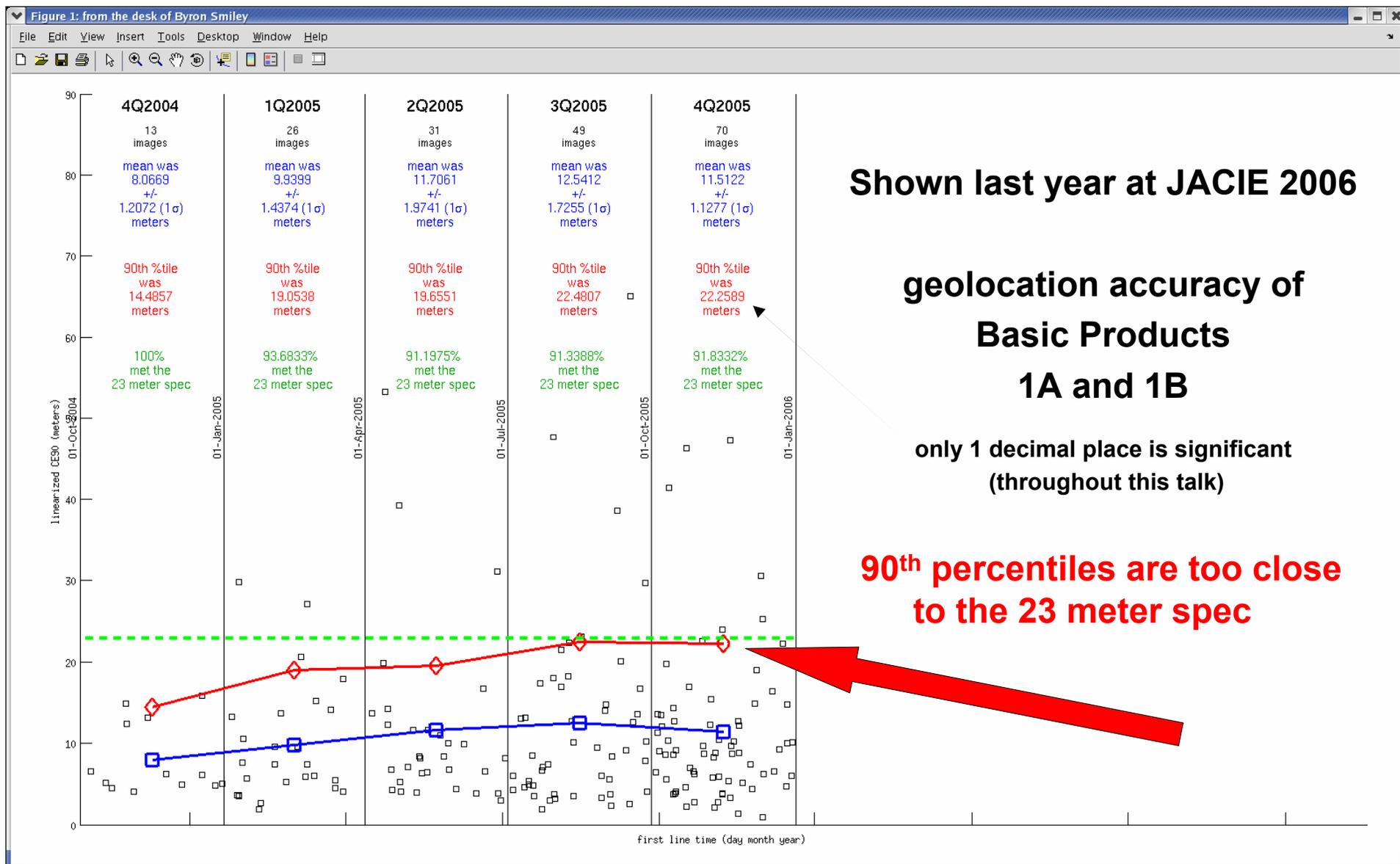
- “linearized” percentile, as opposed to rounding up to the next element to be sure

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



*equal-to-or-less-than percentile: if you have ten things, the 90<sup>th</sup> percentile is the ninth thing*

# Quarterly Geolocation Statistics, 2005



Shown last year at JACIE 2006

geolocation accuracy of  
Basic Products  
1A and 1B

only 1 decimal place is significant  
(throughout this talk)

90<sup>th</sup> percentiles are too close  
to the 23 meter spec

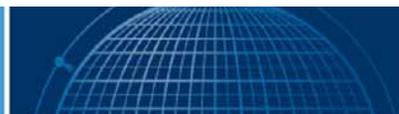


## ADP Refers To Attitude Files

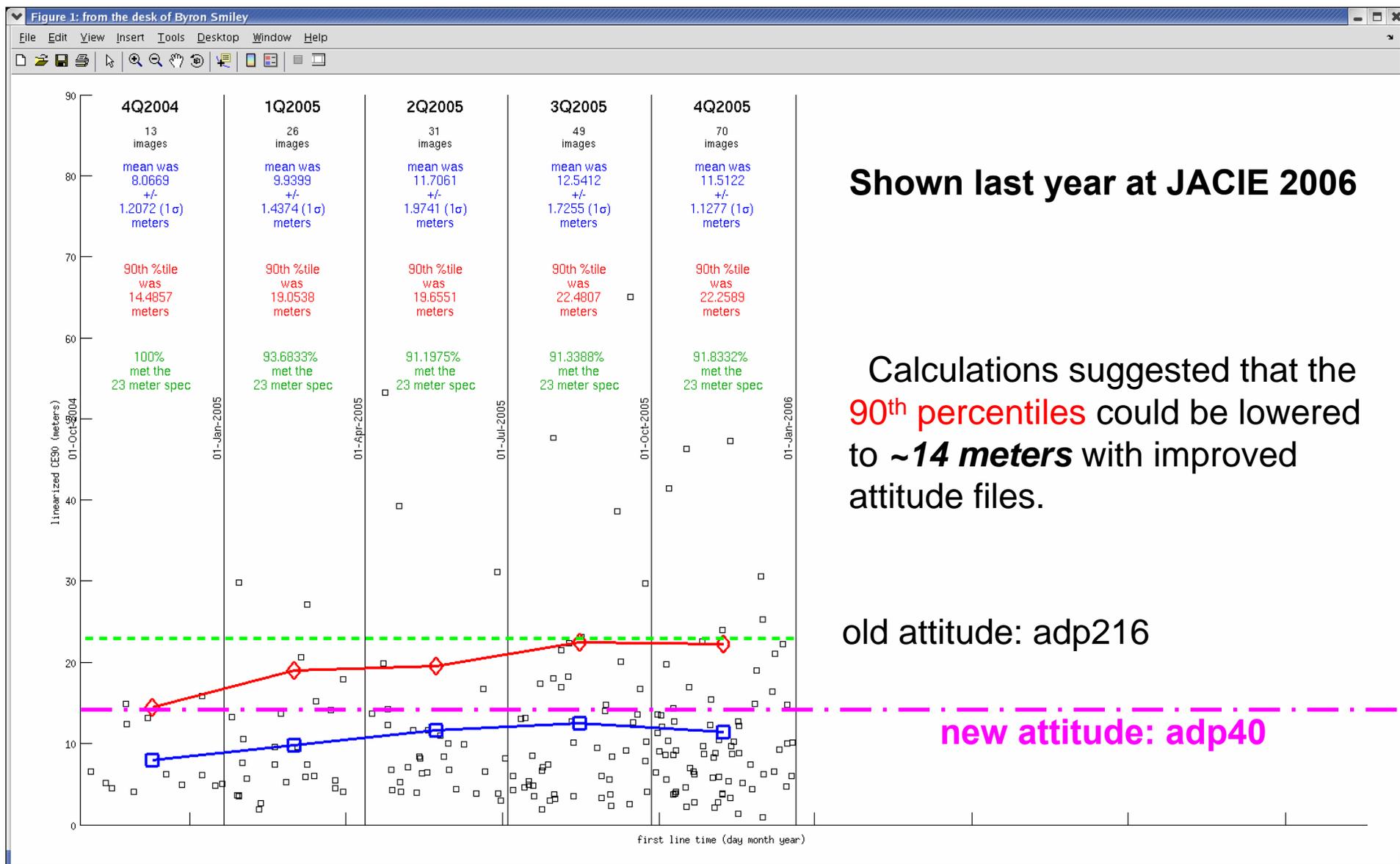
**(A)ttitude (D)etermination (P)rogram**

**old: adp216**

**new: adp40**



# Quarterly Geolocation Statistics, 2005

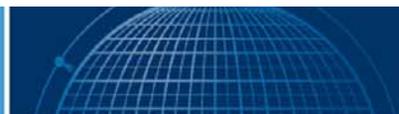


Shown last year at JACIE 2006

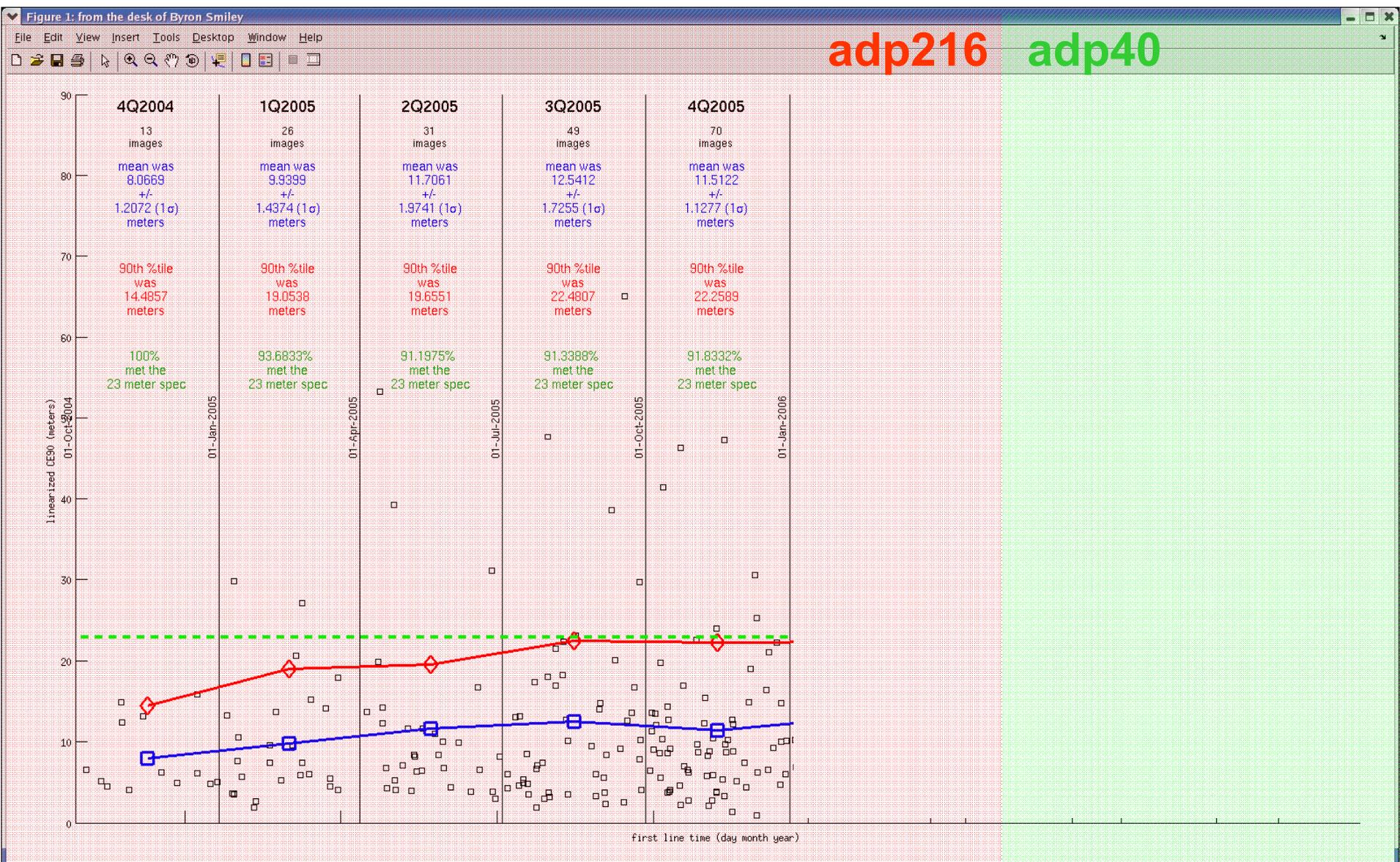
Calculations suggested that the 90th percentiles could be lowered to **~14 meters** with improved attitude files.

old attitude: adp216

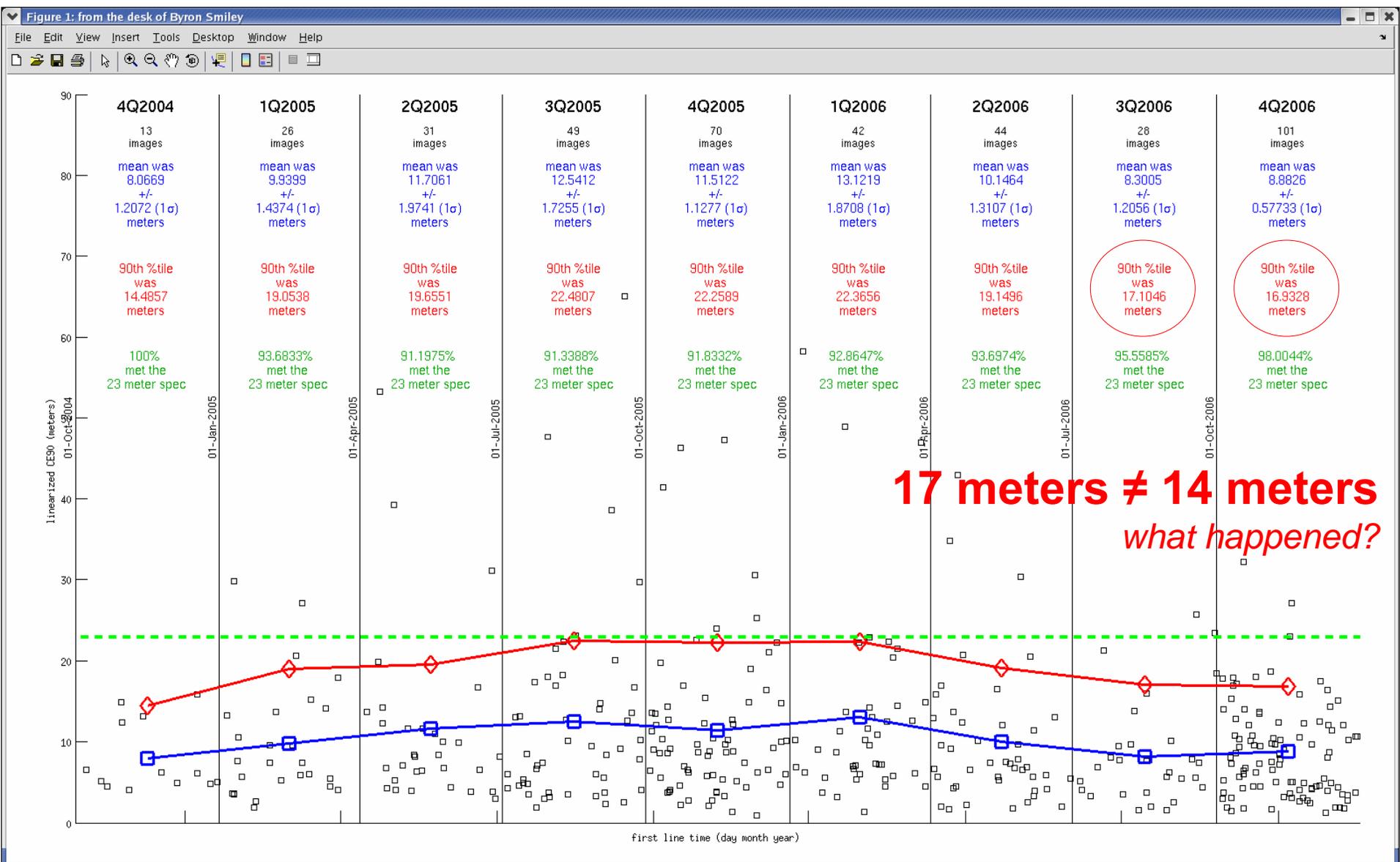
new attitude: adp40



# Quarterly Geolocation Statistics, 2005-2006



# Quarterly Geolocation Statistics, 2005-2006



**17 meters ≠ 14 meters**  
*what happened?*



## Analyze the Improvement in Geolocation

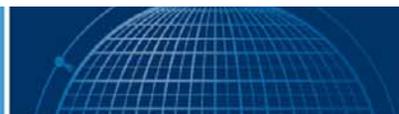
To figure out why quarterly stats did not improve as much as desired,  
zoom in!  
(try monthly bins)

### Advantages

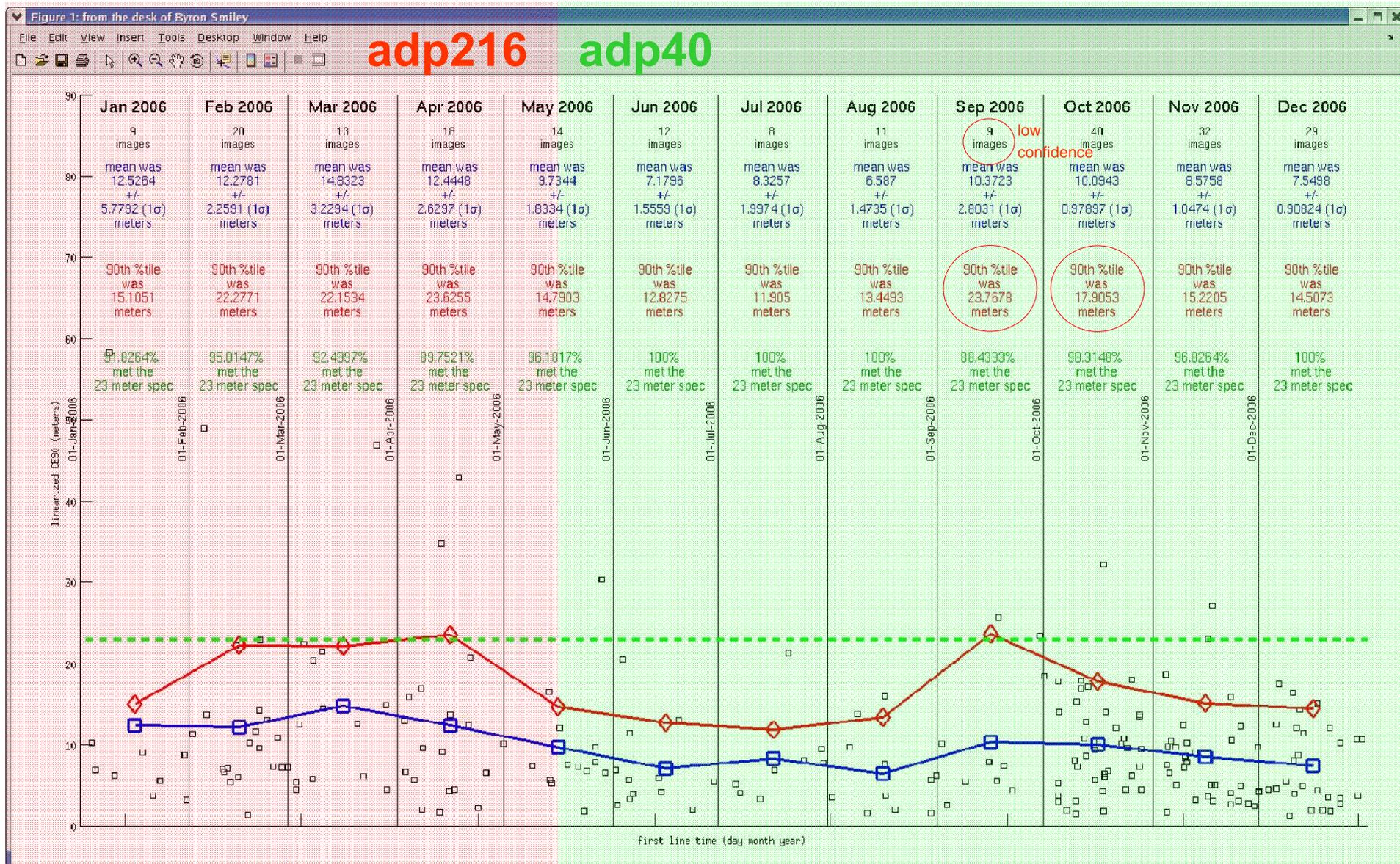
- more bins per year
- more stats

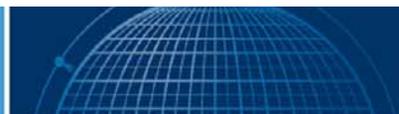
### Disadvantages

- can be few points per bin
  - extremely volatile
- like looking at the Dow Jones...

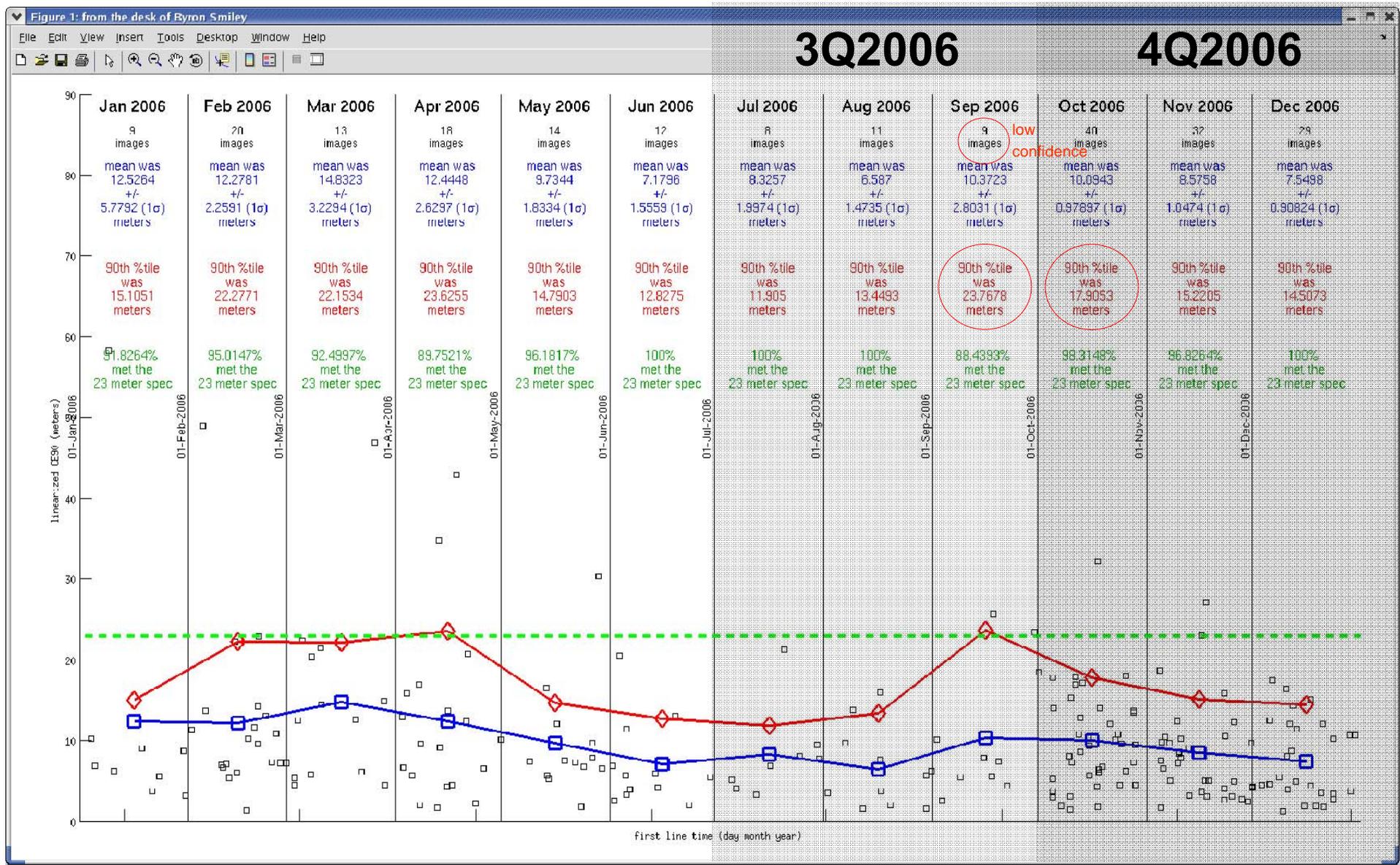


# Monthly Geolocation Statistics, 2006





# How 2 Months Can Ruin 2 Quarters





## Interpretation of the Monthly Plot

**If monthly plot is taken literally,**

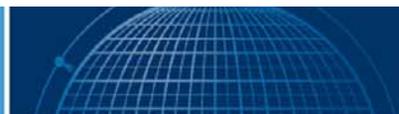
then adp40 really did immediately reduce the 90<sup>th</sup> percentiles (good),

but this also implies something bad happened in Sep, Oct 2006.

**Are there really monthly geocal trends?**

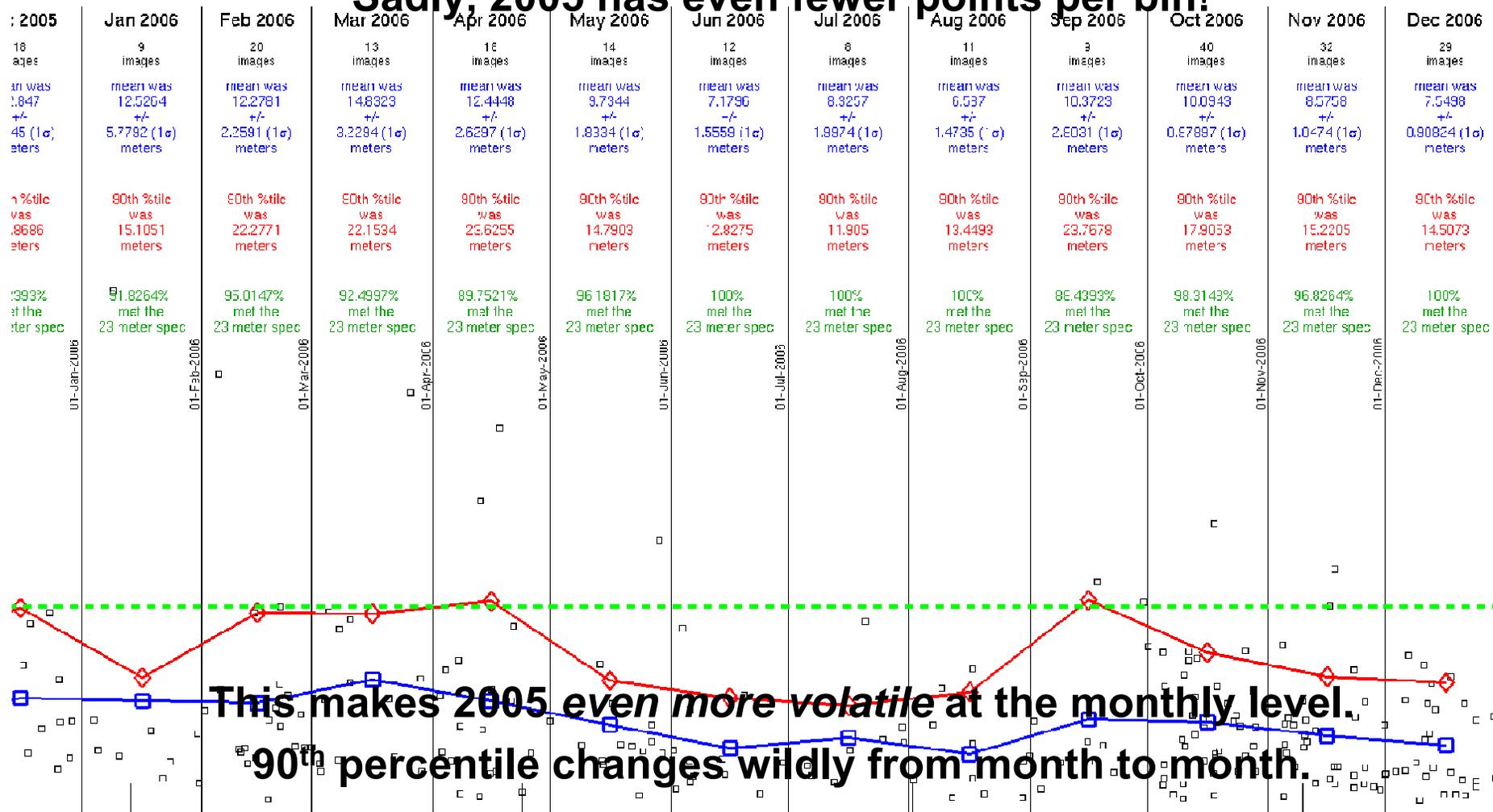
Or are the low sample sizes just misleading?

Examine all the monthly data.



# Monthly Geolocation Statistics, 2005-2006

**Sadly, 2005 has even fewer points per bin!**

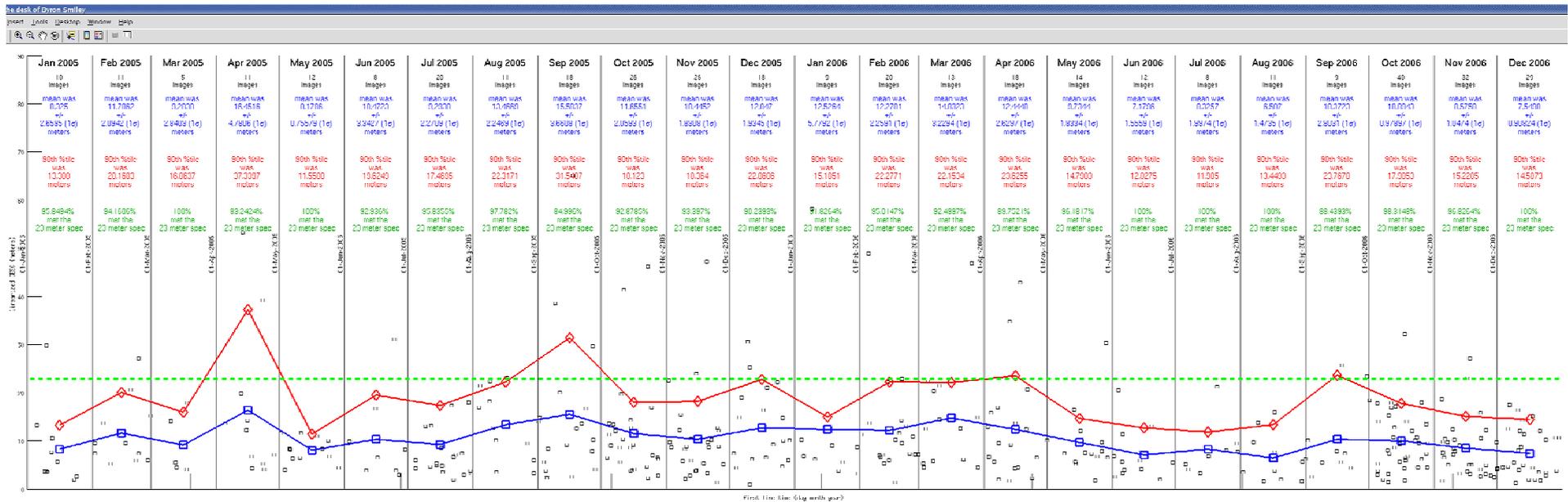


**This makes 2005 even more volatile at the monthly level. 90th percentile changes wildly from month to month.**

t line time (day month year)

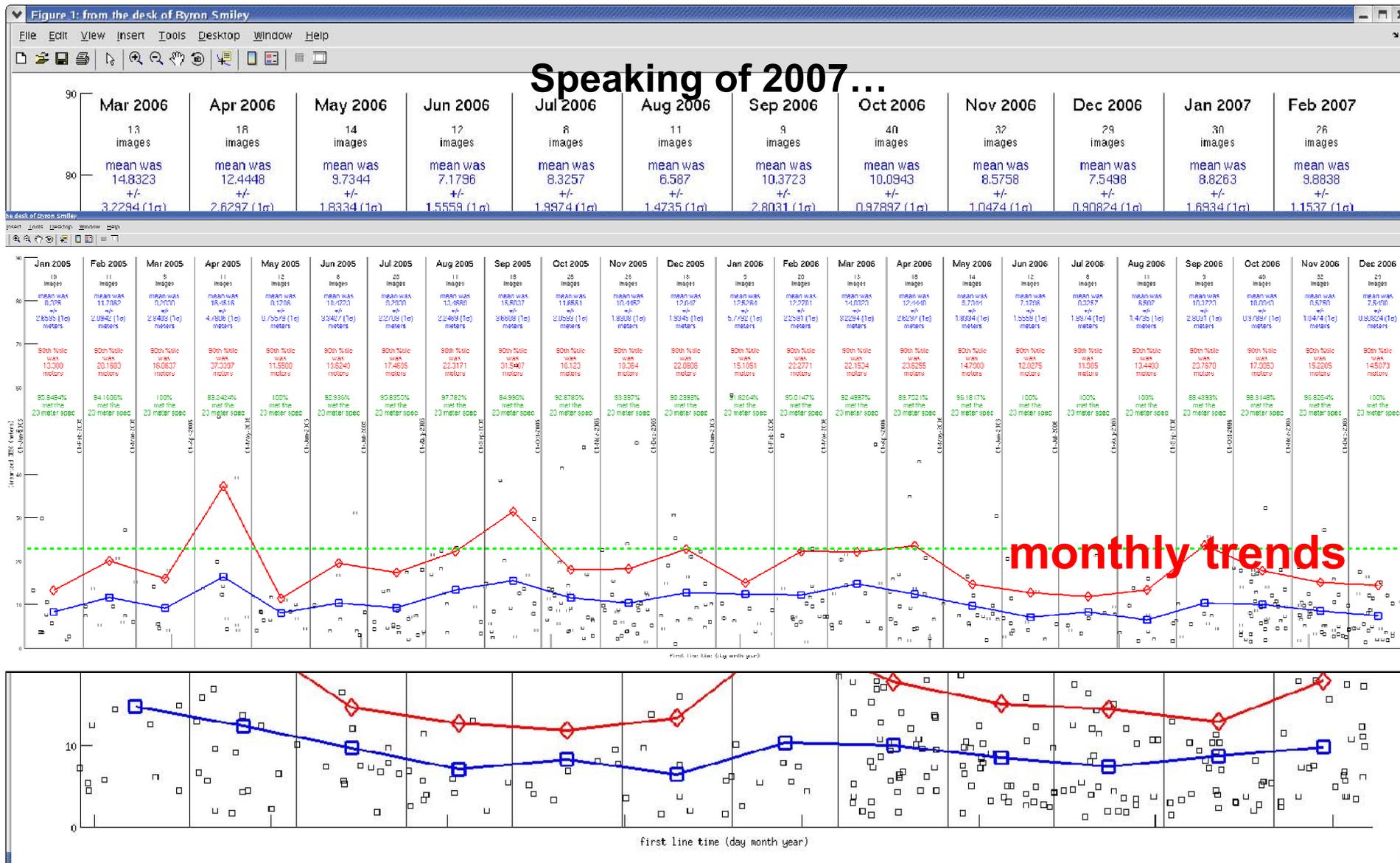
# Monthly Geolocation Statistics, 2005-2006

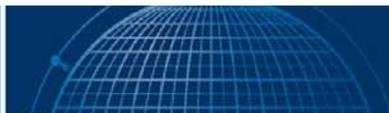
Perhaps there's a pattern in Sep.  
But so few points, can't be certain.



We'll know more in 2007.

# Sneak Peak of 2007





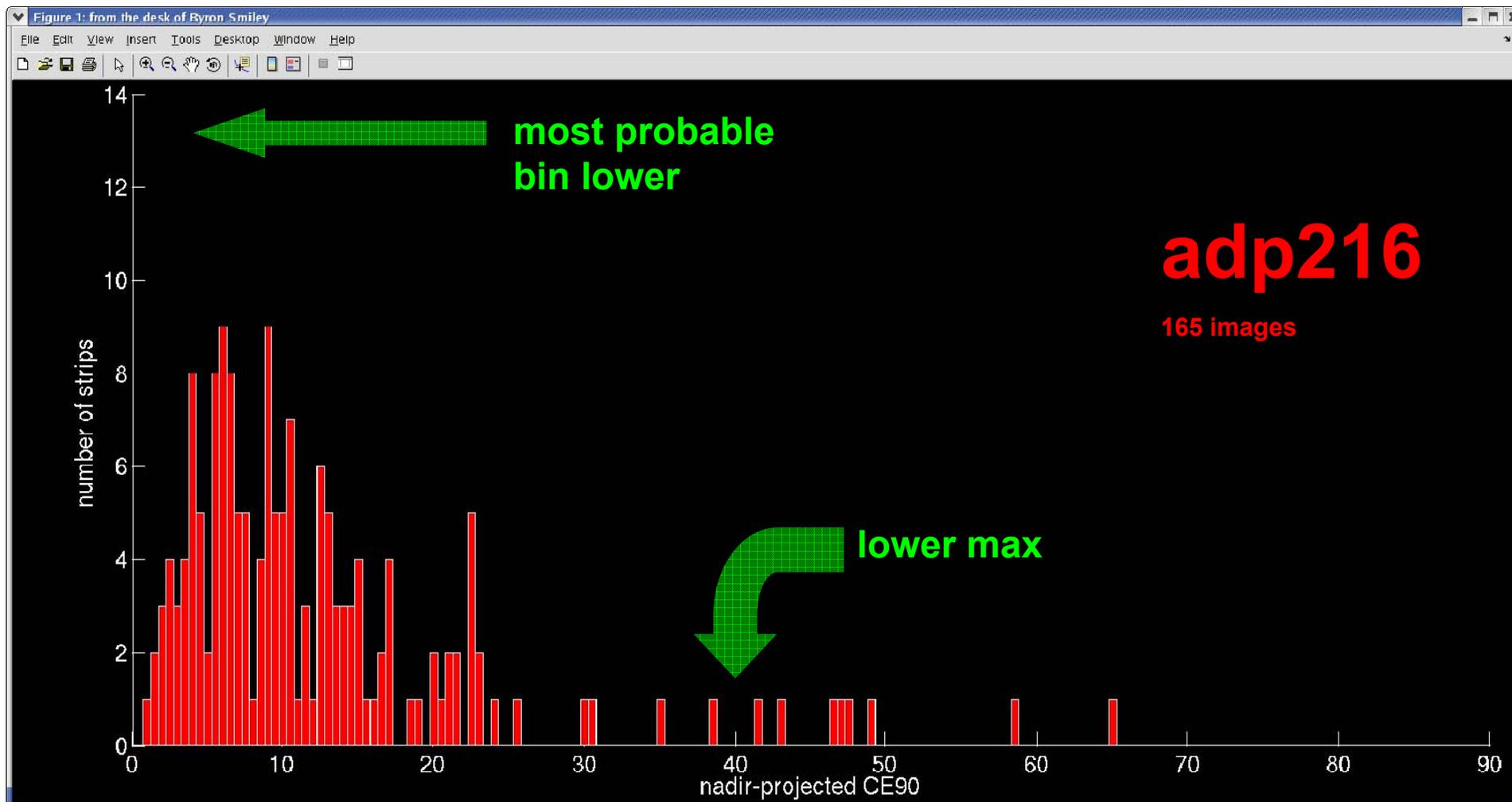
# Histograms

**Remove time as a variable.**

**Pile all the adp40 results together for one last plot.**

# Histograms

Compare equal amounts of time before and after adp40 deployment



(~288 days of data in 0.5 meter bins)



## Conclusions

- **DigitalGlobe has a mature, multi-layered geolocation process.**
  - (actively vs. passively) collected statistics
  - (daily vs. monthly vs. irregular) checks
  - (weekly vs. quarterly vs. irregular) reporting
  
- **adp40 delivers!**
  - quarterly stats improved, but not as much as desired
  - monthly plots show both good and bad spots, bins with few points are probably misleading
  - histograms do show a better distribution



## Conclusions

- **This is all part of an ongoing geolocation improvement program.**
  - all players, tools discussed here will contribute to this goal
  - adp40 was just the beginning
  - strive for at least 30 strips in each month of 2007, to quantify monthly accuracy trends
  - “Sept” anomaly, monthly fluctuations may be next QB02 geolocation issue to be fixed
  - WV01 will enjoy similar monitoring during calibration, operation