

MODIS Geolocation Status

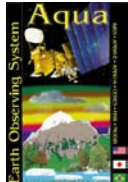
MODIS Science Team Meeting
Calibration Breakout Session

May 9, 2012

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Mash Nishihama and
James Kuyper

MODIS Geolocation Team

NASA GSFC Code 619





Geolocation C5 results

Terra

- Excellent results – C5 Root Mean Square (RMS) error in nadir equivalent units is better than accuracy goal
- Sun angle fit corrects for most of northern/southern hemisphere differences
- Large errors occur ~1.5 hr after maneuvers (about 12 per year)
 - accuracy in following orbit suspect

Along-track RMS error (m)	
Along-scan RMS error (m)	
Years of Data	
Ground Control Point Match-ups/day	

Aqua

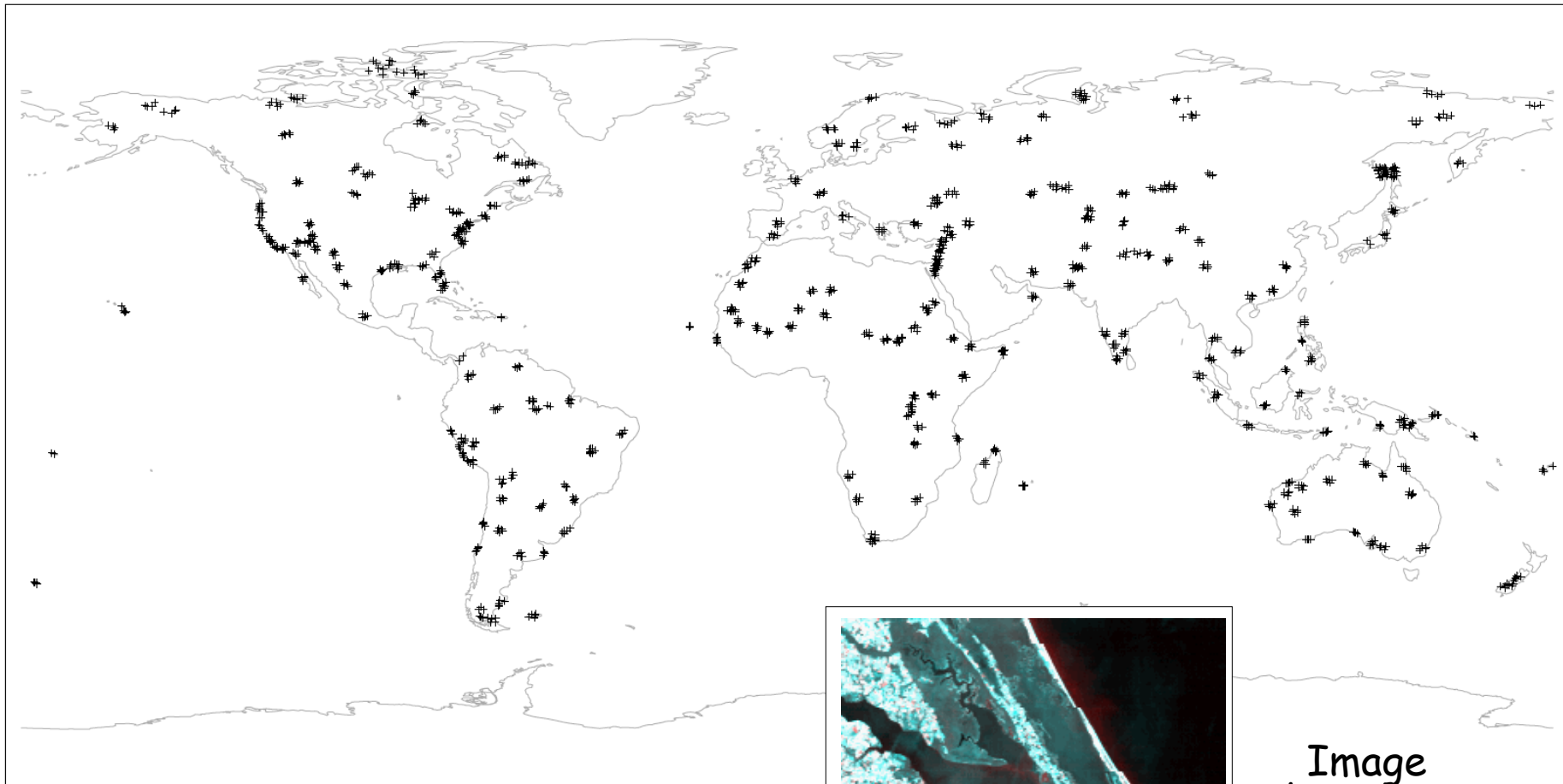
- Good results – C5 RMS error is better than goal in track direction but slightly over goal in scan direction (but much better than specification – 150 m)
- Small remaining northern/ southern hemisphere difference
- Definitive ephemeris is used for best results – causes up to 24 hr processing delay

	Terra	Aqua
Along-track RMS error (m)	43	48
Along-scan RMS error (m)	44	53
Years of Data	12.1	9.8
Ground Control Point Match-ups/day	264	228

Note: These results are for MODIS Band 1, which is used in the control point matchup. Other bands must be offset by the band-offsets published by the MODIS calibration team.



Ground Control Points (GCPs)



1214 GCPs used in C5

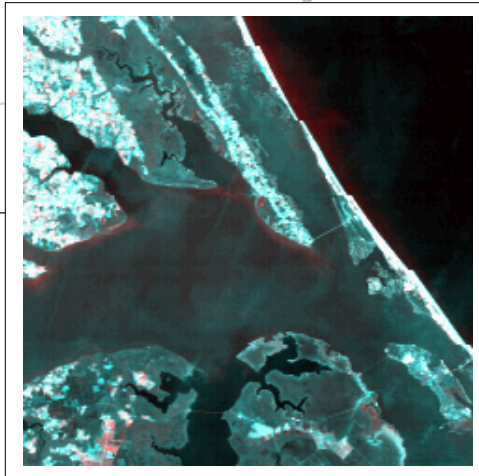


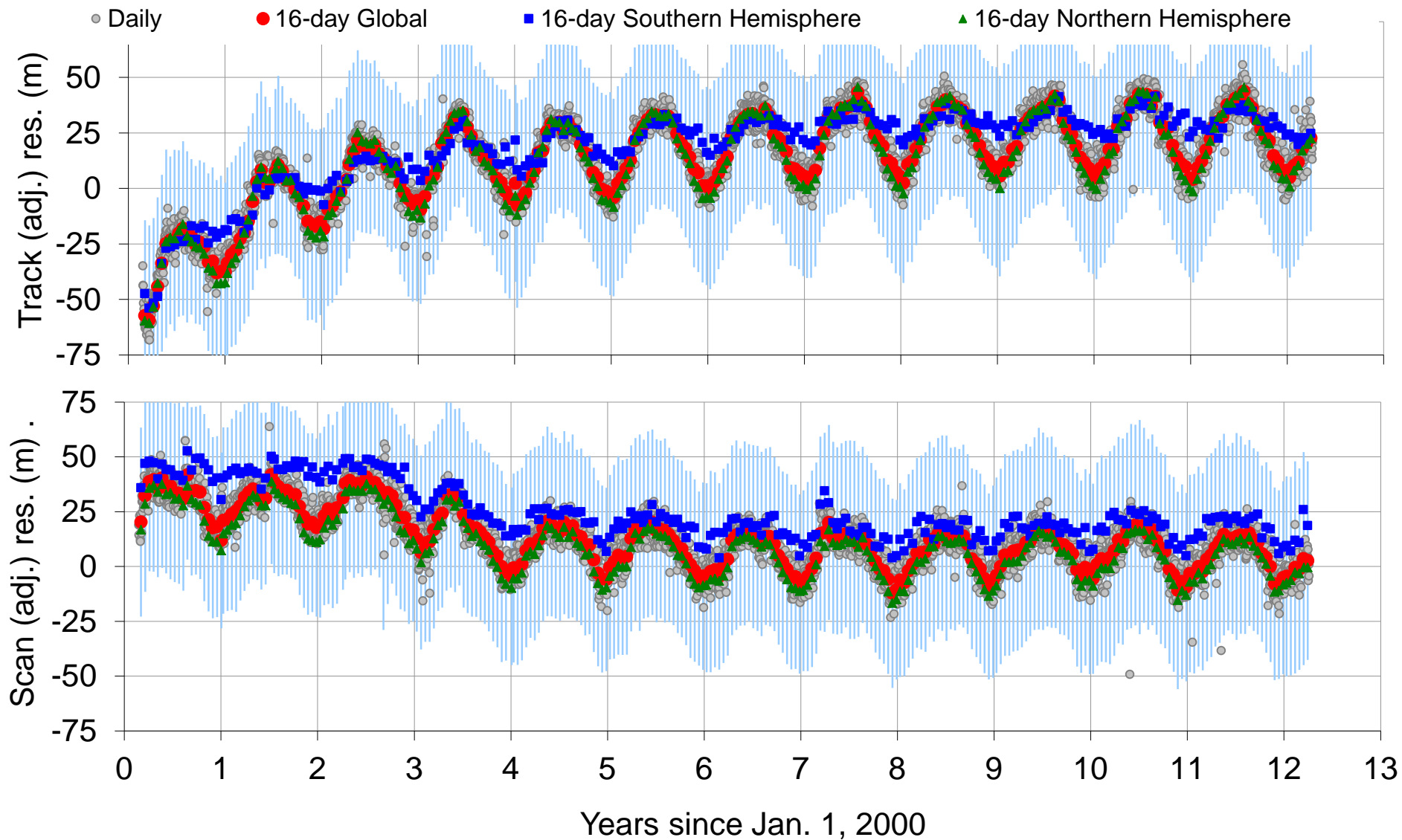
Image chips from Landsat TM/ETM scenes



Terra trend and update details



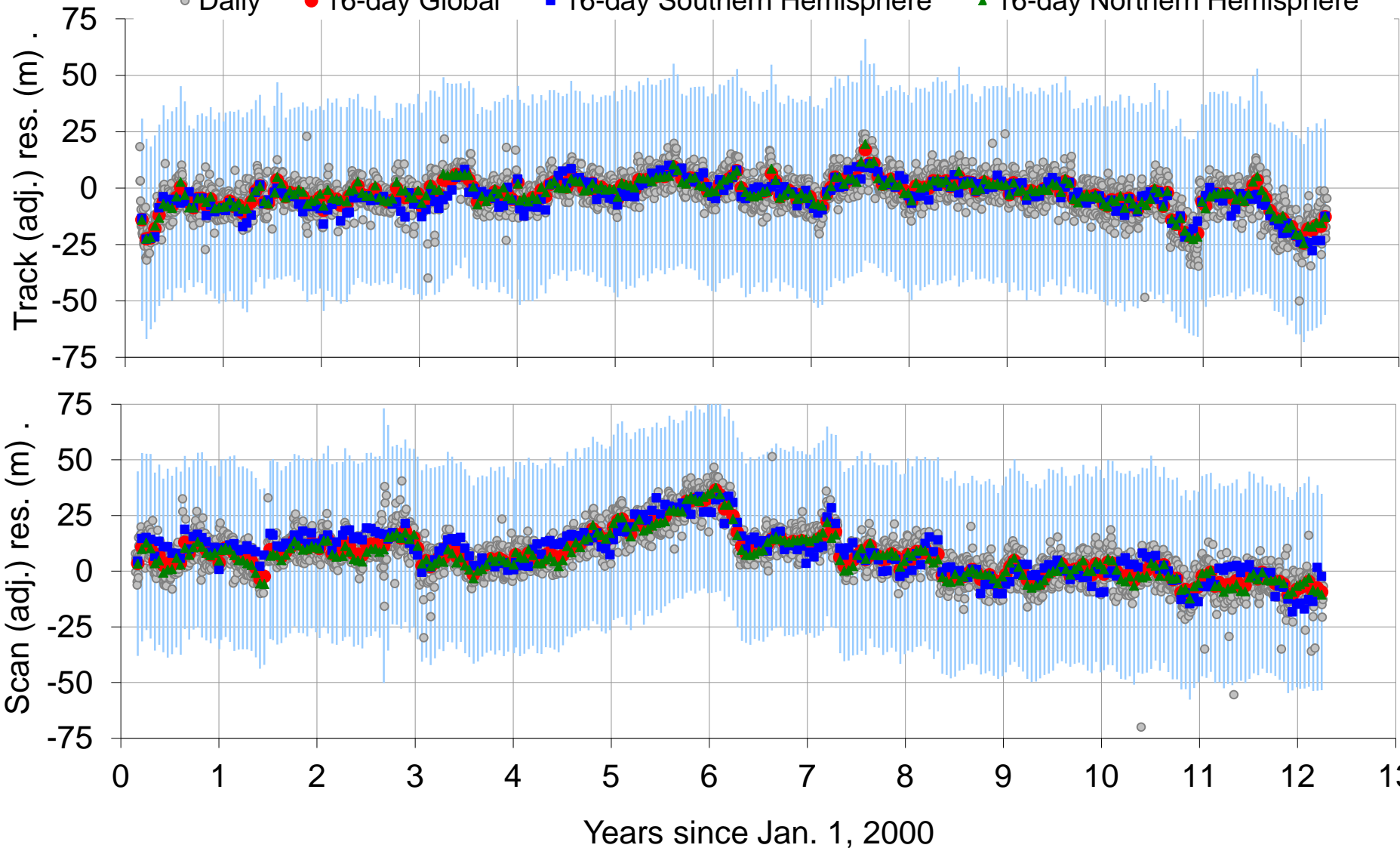
Terra long-term trend (w/o correction)





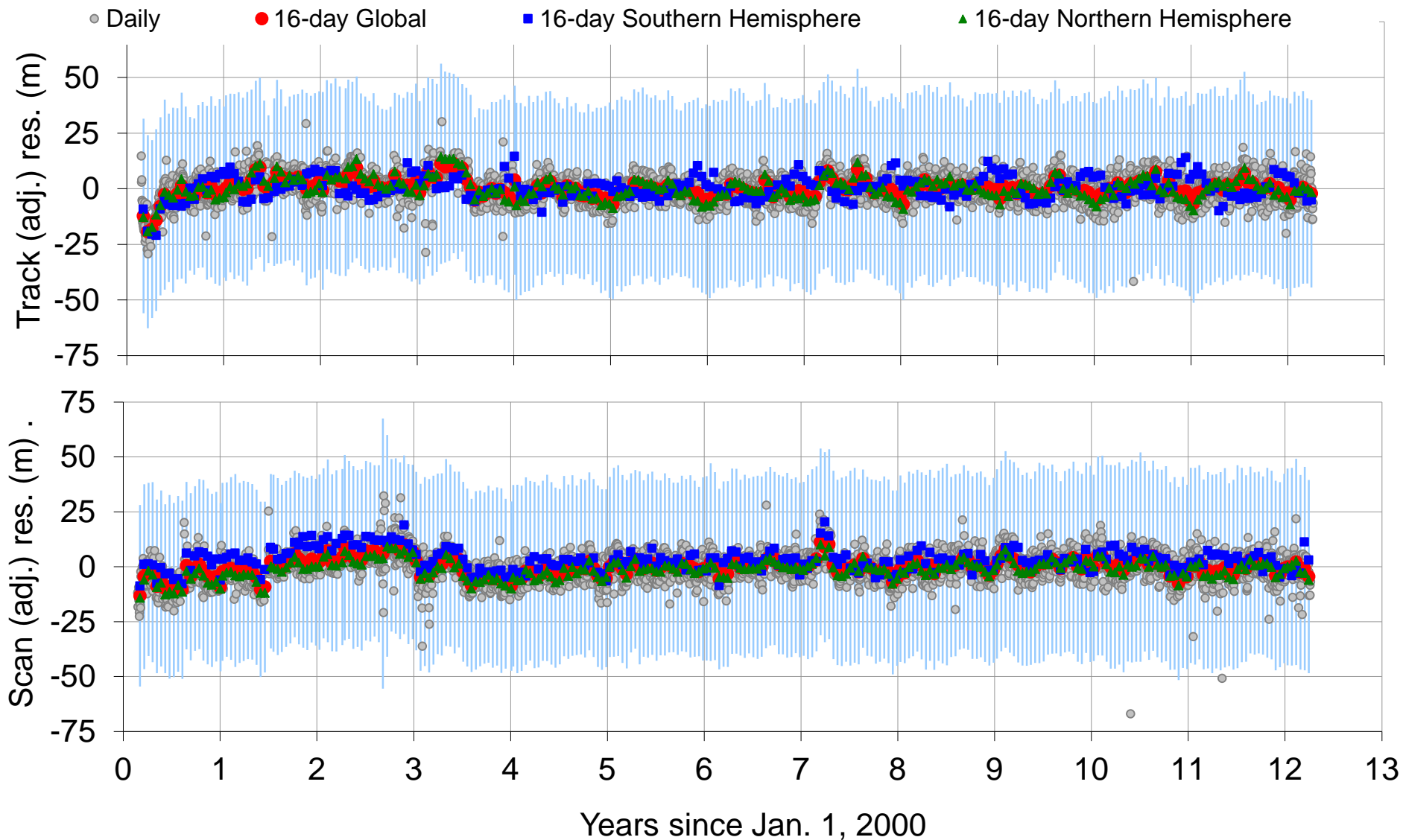
Actual Terra C5 residuals

○ Daily ● 16-day Global ■ 16-day Southern Hemisphere ▲ 16-day Northern Hemisphere





Expected Terra C6 residuals

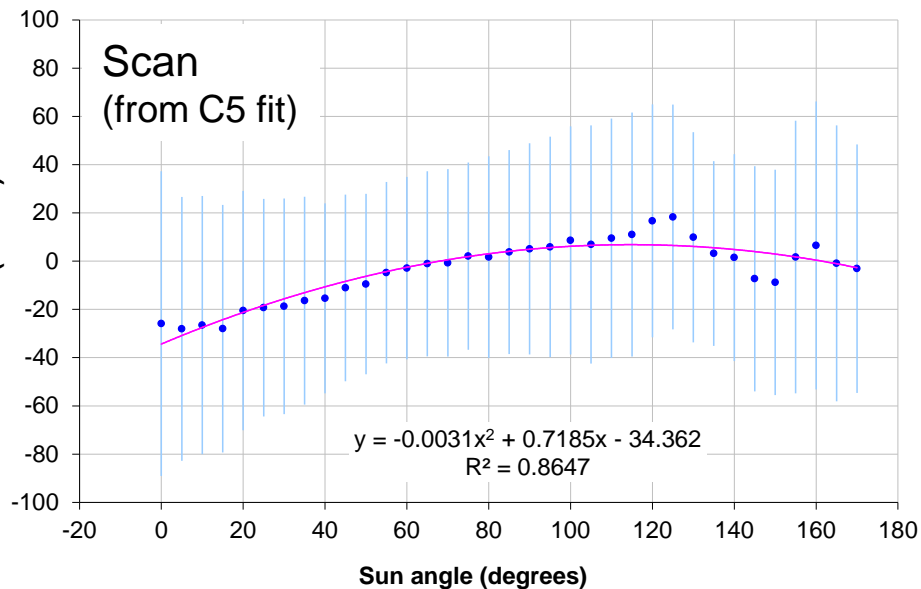
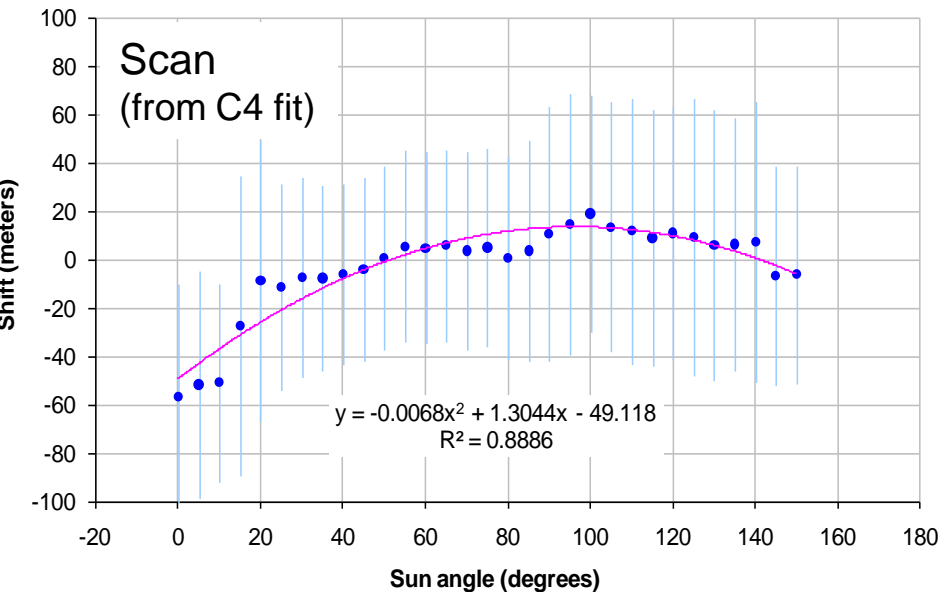
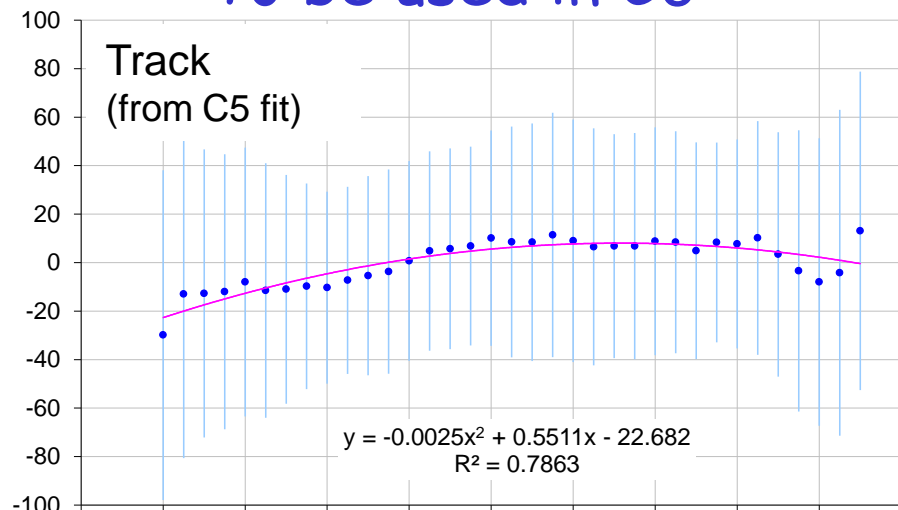
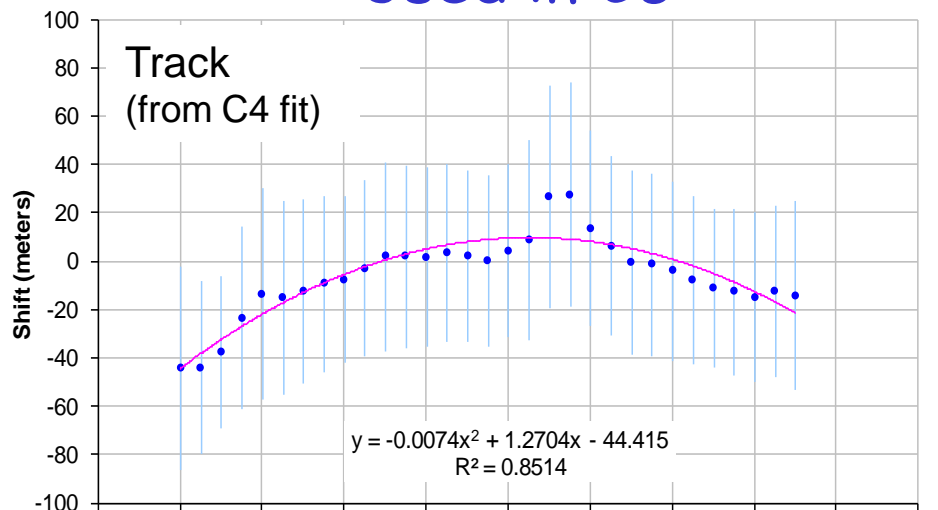




Terra Sun angle Correction

Used in C5

To be used in C6





Terra C6 geometric parameter changes

- Change in geometric biases and scan mirror rate
 - Based on global hierarchical maximum decent search
 - Main changes in track direction are in split between spacecraft to instrument pitch and telescope tilt values
 - Small changes to mirror parameters (alpha, beta and gamma)
 - Sample time bias (delta added to nominal 0.333333 sec)

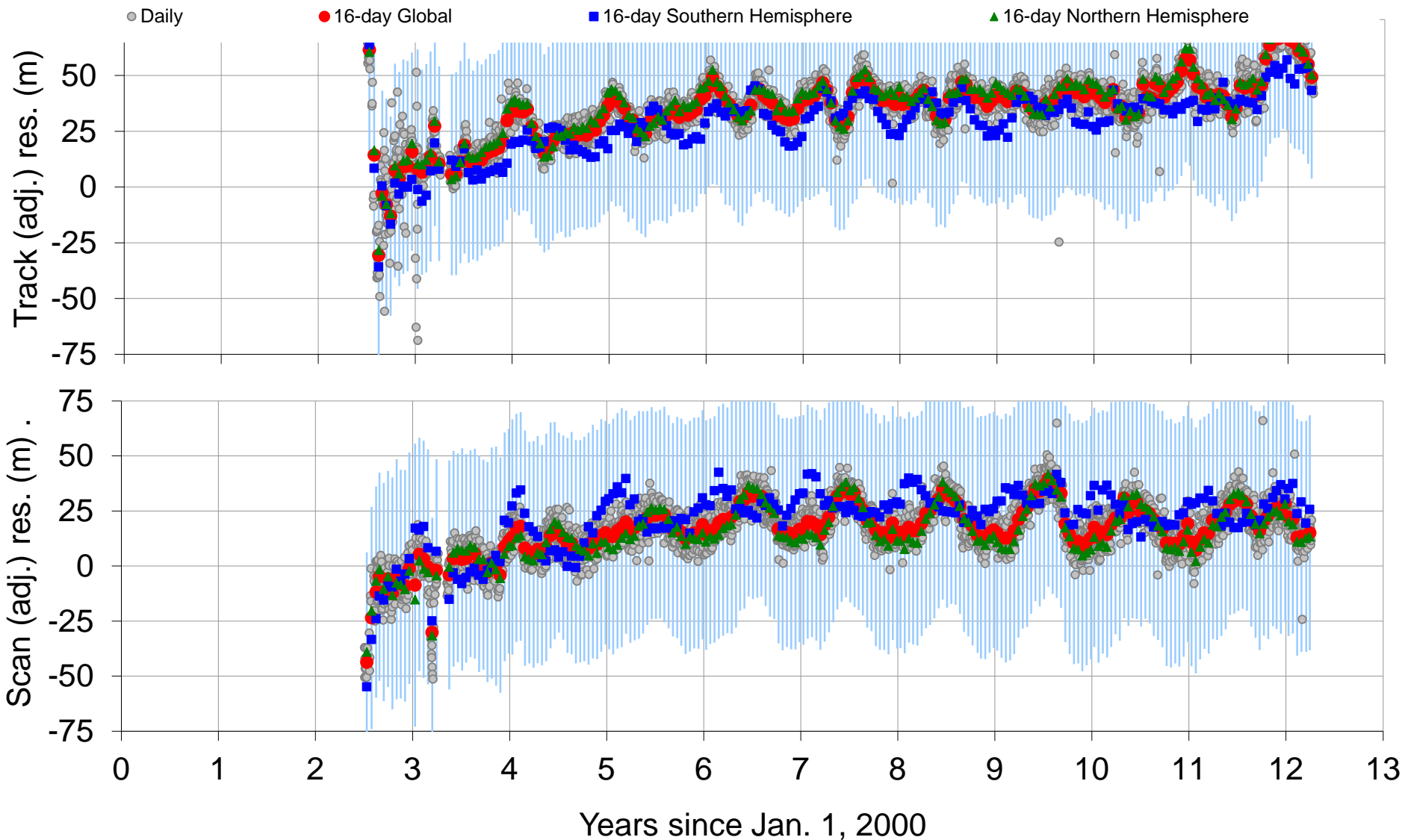
Bias	Units	C5	C6	Diff
s/c to inst – roll	arcsec	251.8	251.8	0.0
s/c to inst – pitch	arcsec	83.4	129.4	46.0
s/c to inst – yaw	arcsec	97.9	97.9	0.0
mirror – alpha	arcsec	-4.1	-3.3	0.8
mirror – beta	arcsec	38.0	40.0	2.0
mirror – gamma	arcsec	-0.6	-0.7	-0.1
telescope – tilt	arcsec	-180.6	-218.7	-38.1
sample time (delta)	nsec	0.0	3.1	3.1



Aqua trend and update details



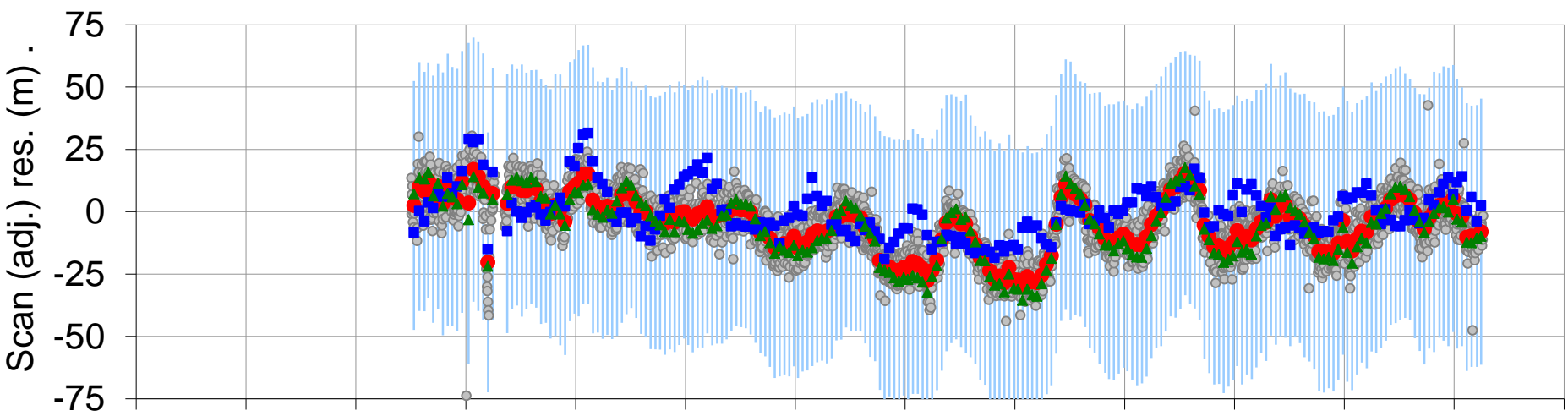
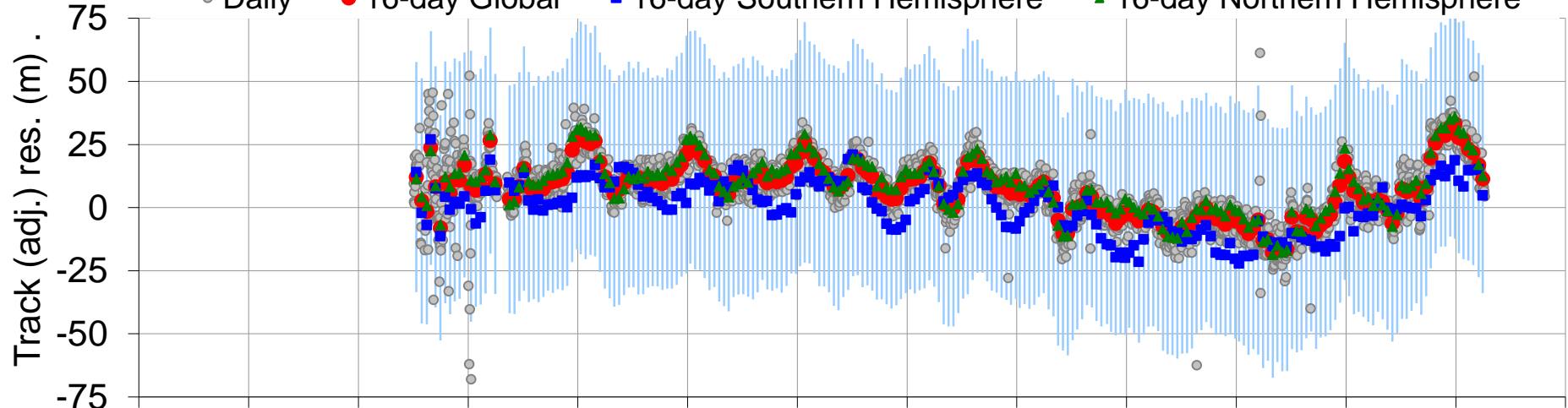
Aqua Long-term Trend (w/o Correction)





Actual Aqua C5 residuals

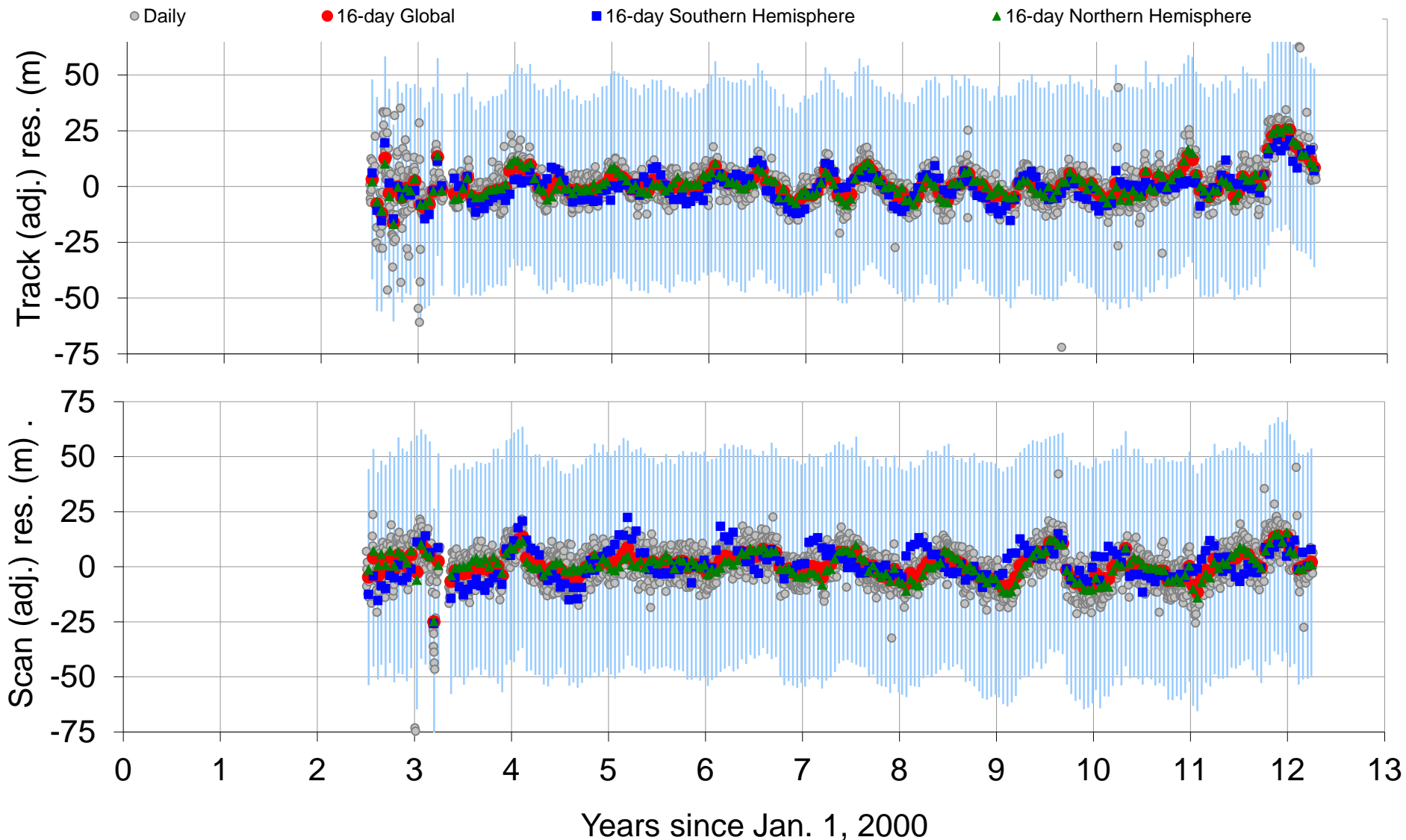
○ Daily ● 16-day Global ■ 16-day Southern Hemisphere ▲ 16-day Northern Hemisphere



Years since Jan. 1, 2000



Expected Aqua C6 residuals

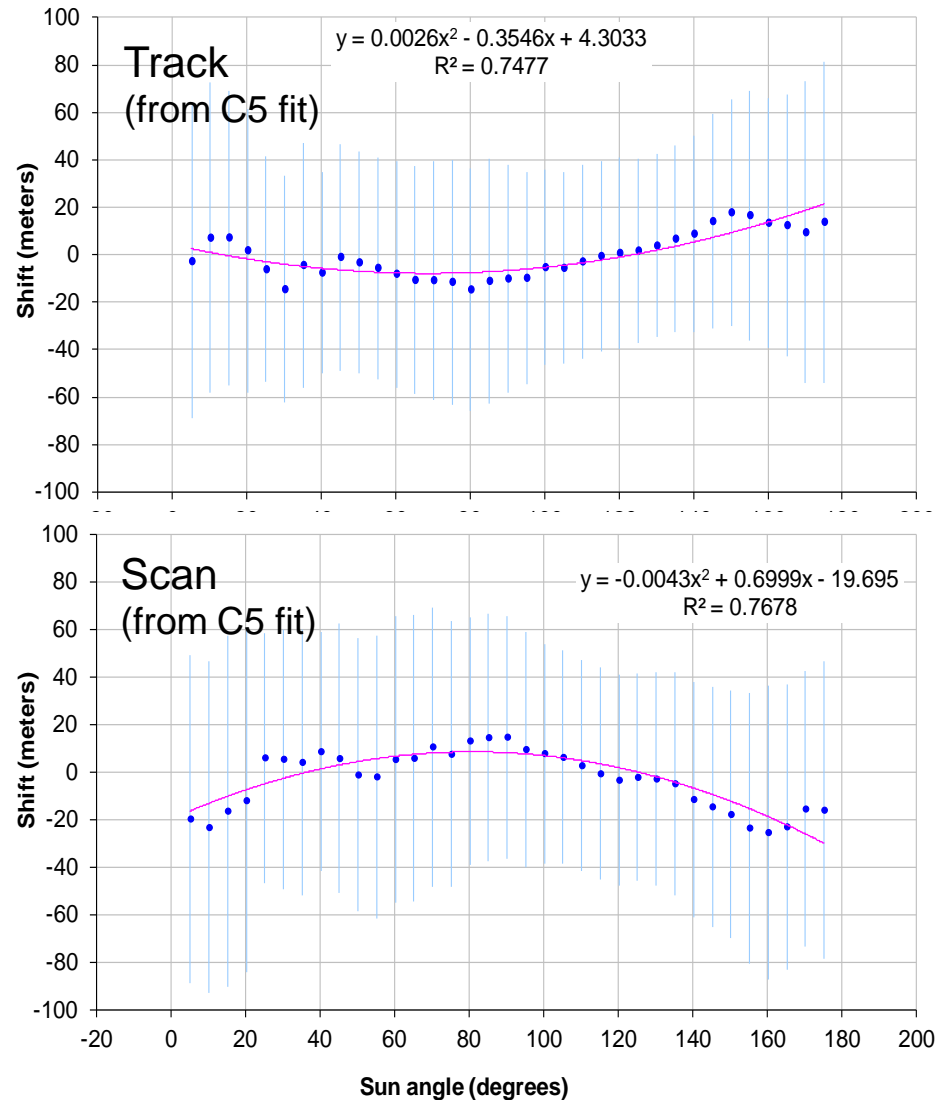




Aqua Sun angle Correction

Track and Scan sun-angle effects

- no correction in C5
- will be corrected in C6





Aqua C6 geometric parameter changes

- Change in geometric biases and scan mirror rate
 - Based on global hierarchical maximum decent search
 - Small changes to telescope tilt and mirror parameters (alpha, beta and gamma)
 - Sample time bias (delta added to nominal 0.333333 sec)

Bias	Units	C5	C6	Diff
s/c to inst – roll	arcsec	409.6	409.6	0.0
s/c to inst – pitch	arcsec	582.1	582.1	0.0
s/c to inst – yaw	arcsec	-76.3	-76.3	0.0
mirror – alpha	arcsec	-5.6	-6.2	-0.6
mirror – beta	arcsec	37.1	37.0	-0.1
mirror – gamma	arcsec	-6.4	-5.9	0.5
telescope – tilt	arcsec	-422.2	-420.6	1.6
sample time (delta)	nsec	0.0	6.6	6.6



Maneuver Handling and C6 Changes

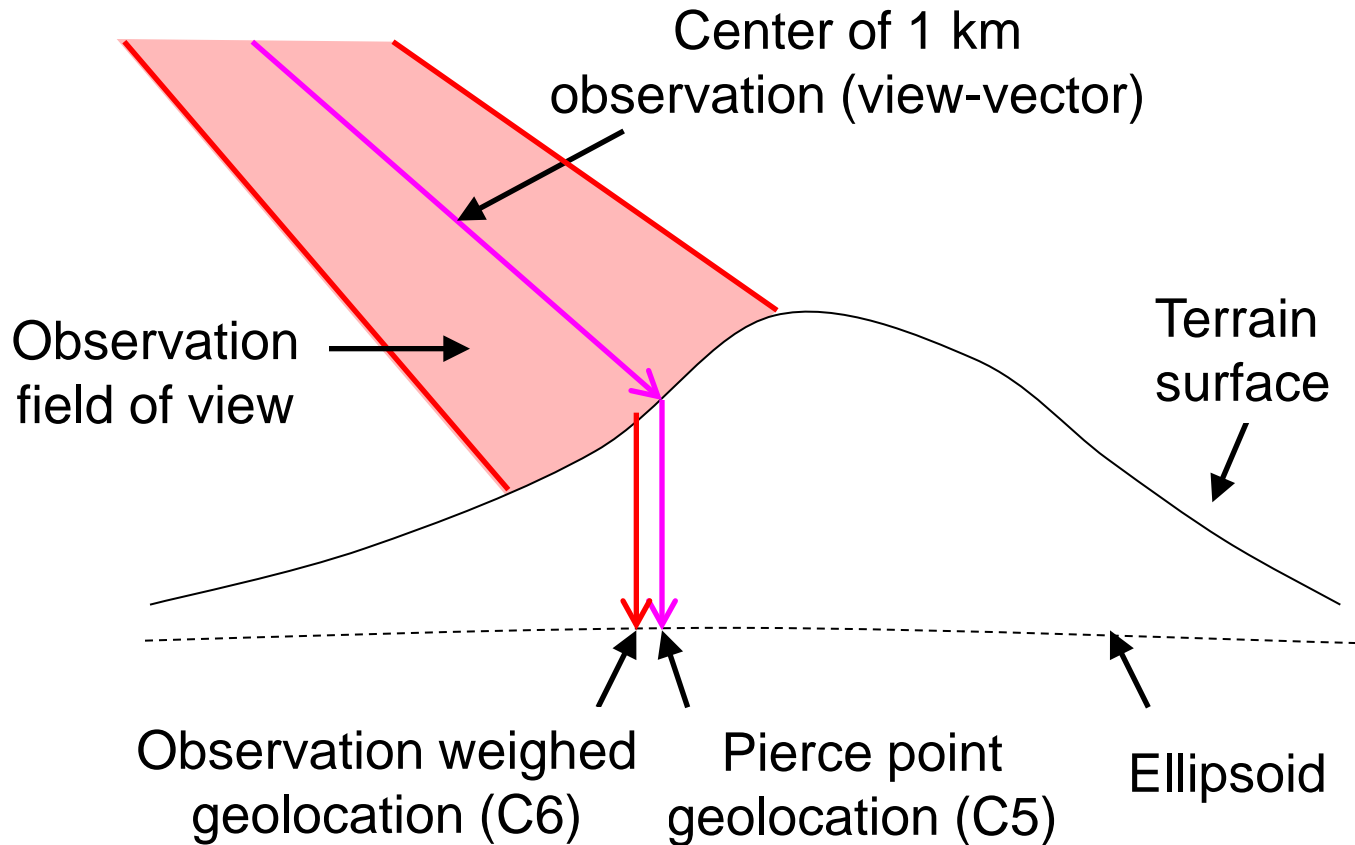


Maneuver Handling

- Definitive maneuver lists (for both Aqua and Terra) are being obtained regularly from FOT
- LDOPE routinely screens data near maneuvers to exclude this data from daily and higher level products
- Atmosphere hides L2+ products when geolocation errors exceed 1km
- For C6 the geolocation team will continue to work with the Terra and Aqua FOTs to find a better solution (no real progress yet)

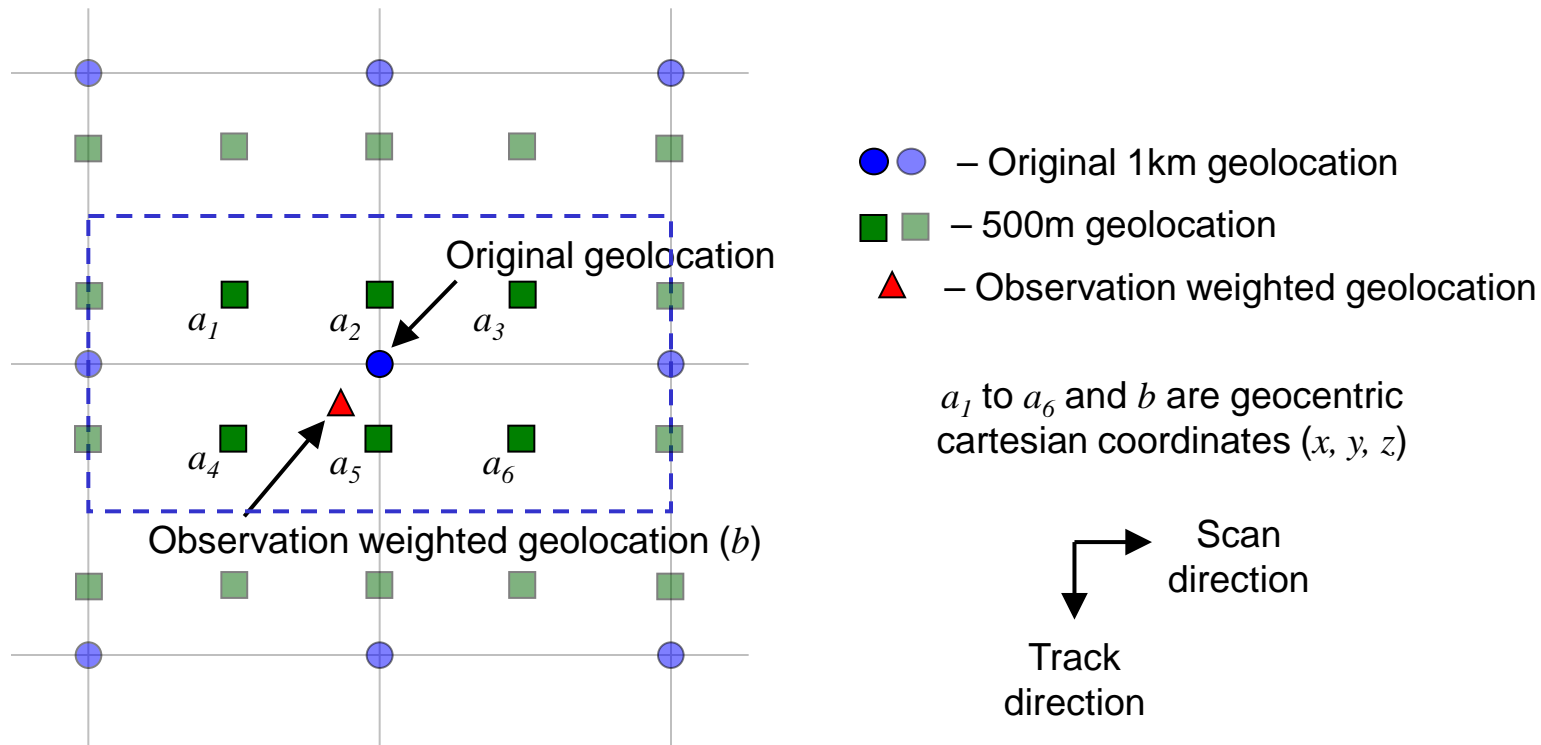


C6 observation weighted terrain correction





Observation weighted terrain correction



The first order approximation of the observation weighted point is:

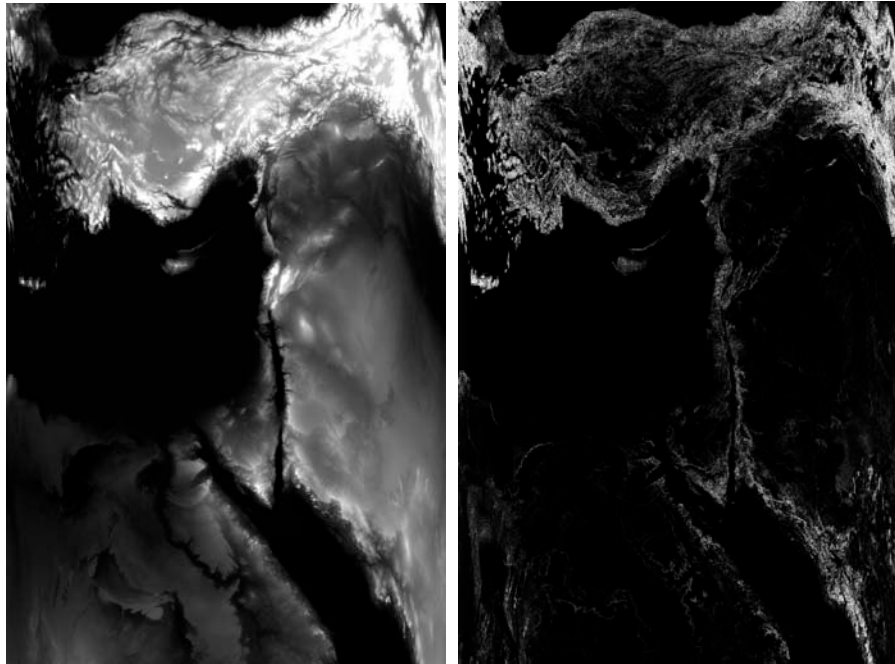
$$b = \frac{(a_1 + a_3 + a_4 + a_6) w_1 + (a_2 + a_5) w_2}{4 w_1 + 2 w_2}$$

where $w_1 = 1$ and $w_2 = 2$. These weights approximate the **triangular** time-integrated weighting function in the **scan** direction and the **rectangular** weighting function in the **track** direction.



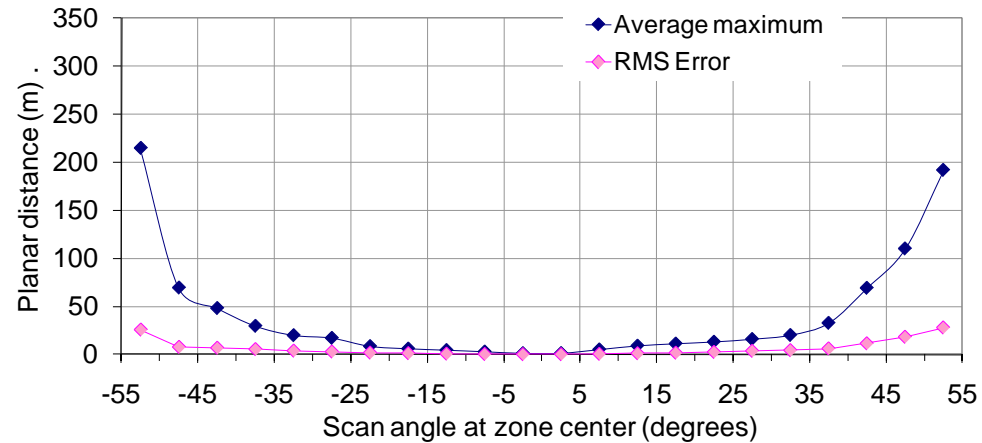
Example: Terra - Middle east

2001/199.0840



Geolocation Elevation
(black: -27m, white: 2069m)

Geolocation difference
current minus obs. weighted
(black: 0m, white: 52m)



New for C6: 500m geolocation (pierce point) is also available, stored as offsets from 1km geolocation (observation weighed)

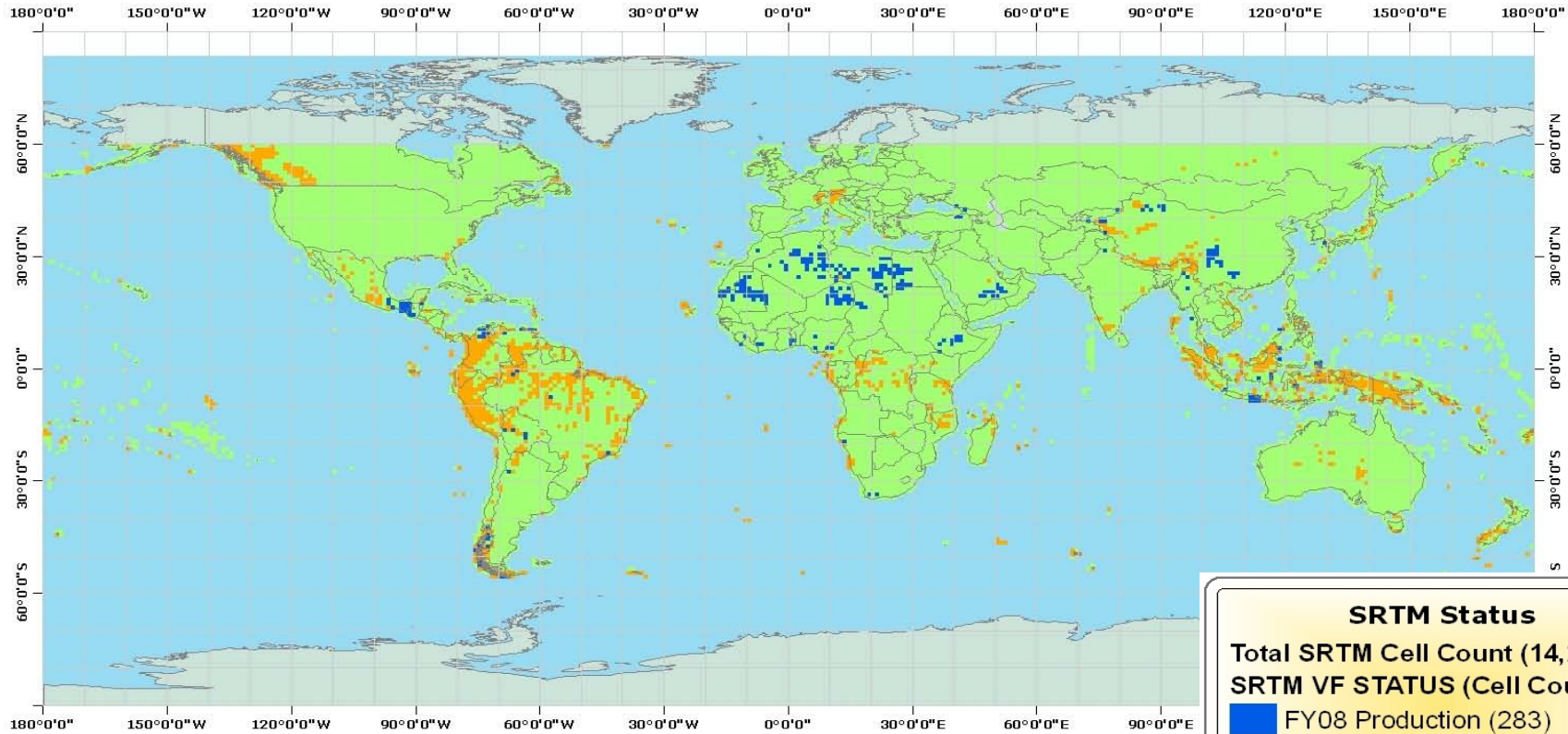


New C6 DEM

- Current C5 DEM
 - SRTM based gap filled
 - Uncertain about the heritage of the approach to reducing resolution and gap filling
 - Only available at 30 arc-sec (~1km) DEM
- New C6 DEM (Source: USGS and NGA, Danielson et al.)
 - Being used at 15 arc-sec (~500m)
 - Better data is now available for gap filling
 - Using best available approach to reducing resolution and gap filling



SRTM Voids



SRTM Status

Total SRTM Cell Count (14,277)

SRTM VF STATUS (Cell Count)

- FY08 Production (283)
- Complete Full Cells (12,708)
- Incomplete Partial Cells (1,287)

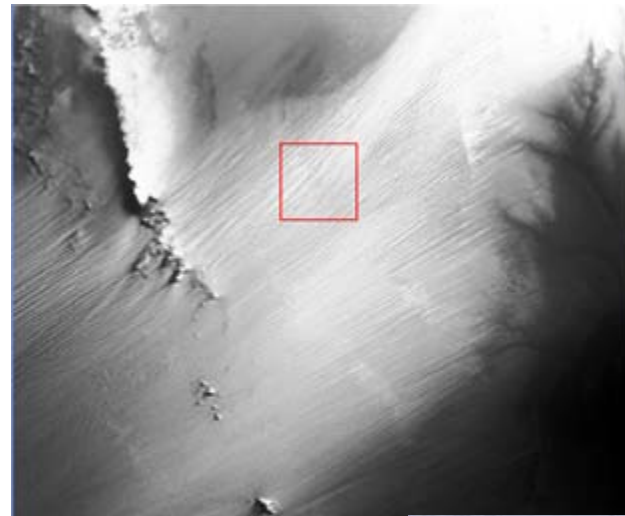
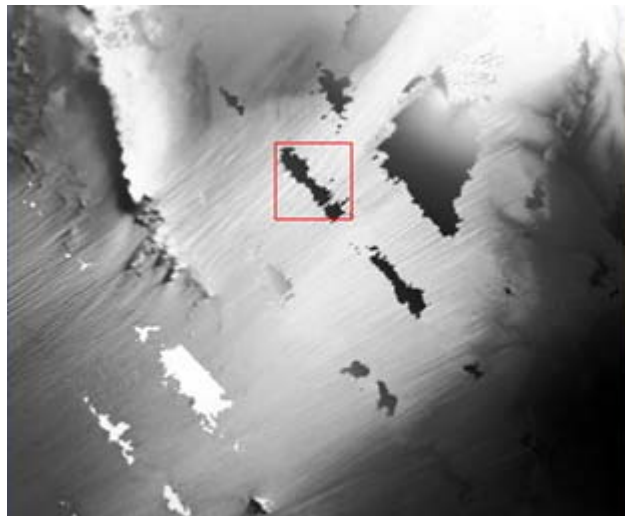
- Causes for SRTM voids:

- Limited duty cycle aboard the sensor (large area blocks)
- High relief areas (shadow and layover)
- Poor correlation of radar images in desert landscapes due to sand surface texture

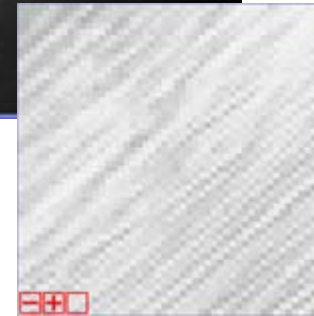


Old vs. New DEM

MODIS Geolocation Height (data-day 2010/221)



Current DEM
(C5)



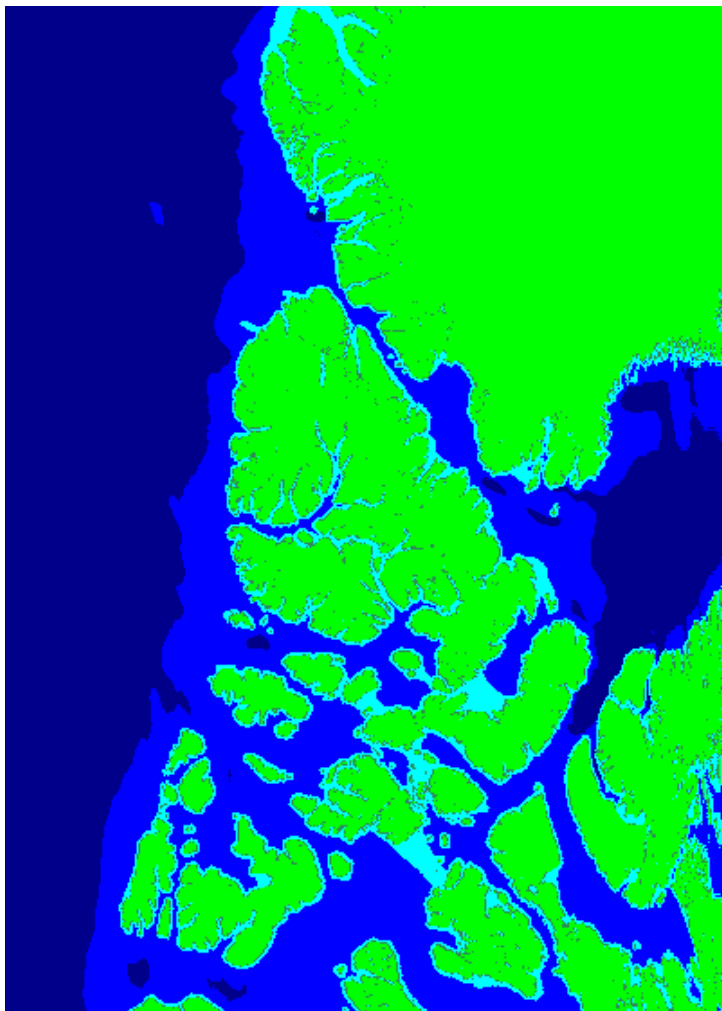
New DEM
(C6)



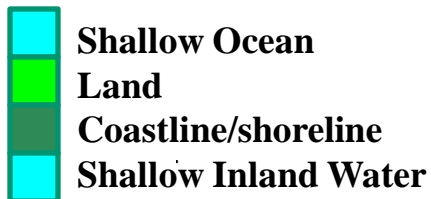
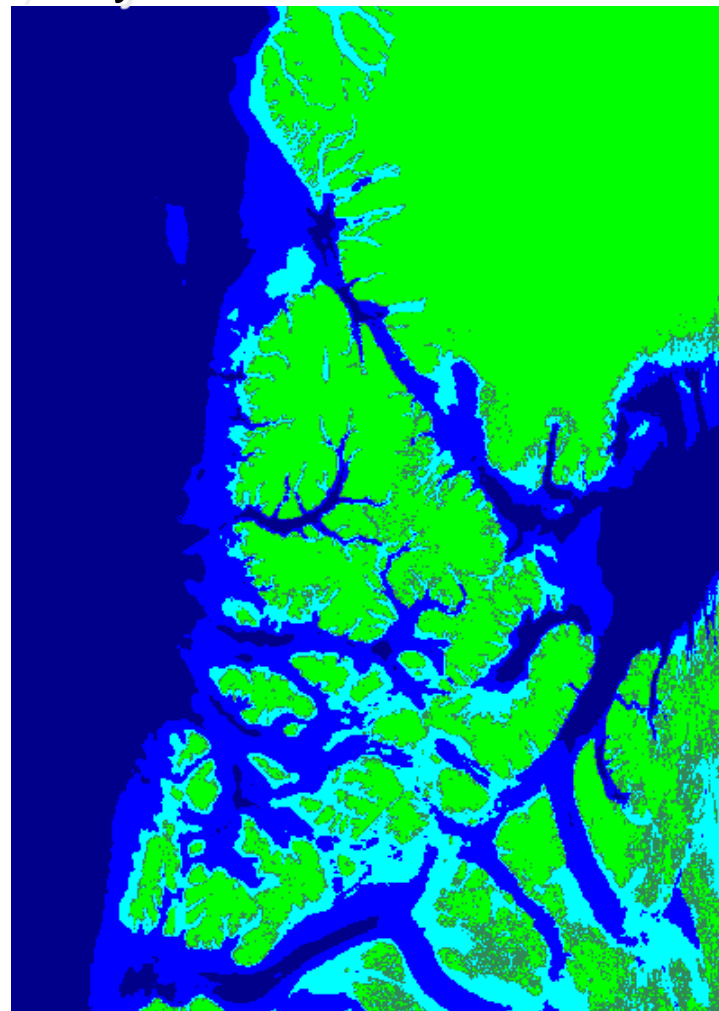
New Land Water Mask in C6 MOD03

Terra Granule 19:25, Day 2003-193

C5

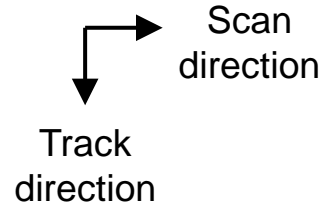
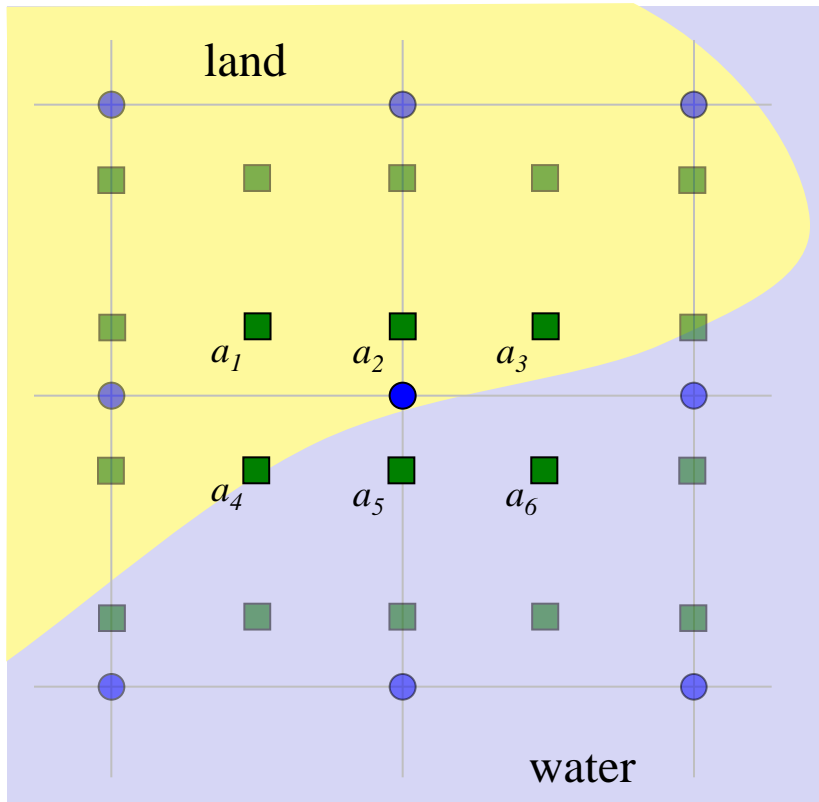


C6





Water present method at 1km



- — Original 1km geolocation
- — 500m geolocation

a_1 to a_6 are either
0 for any land or coast class;
or 1 for any water class

The water present value b (range 0 to 8) is

$$b = (a_1 + a_3 + a_4 + a_6) + 2(a_2 + a_5)$$

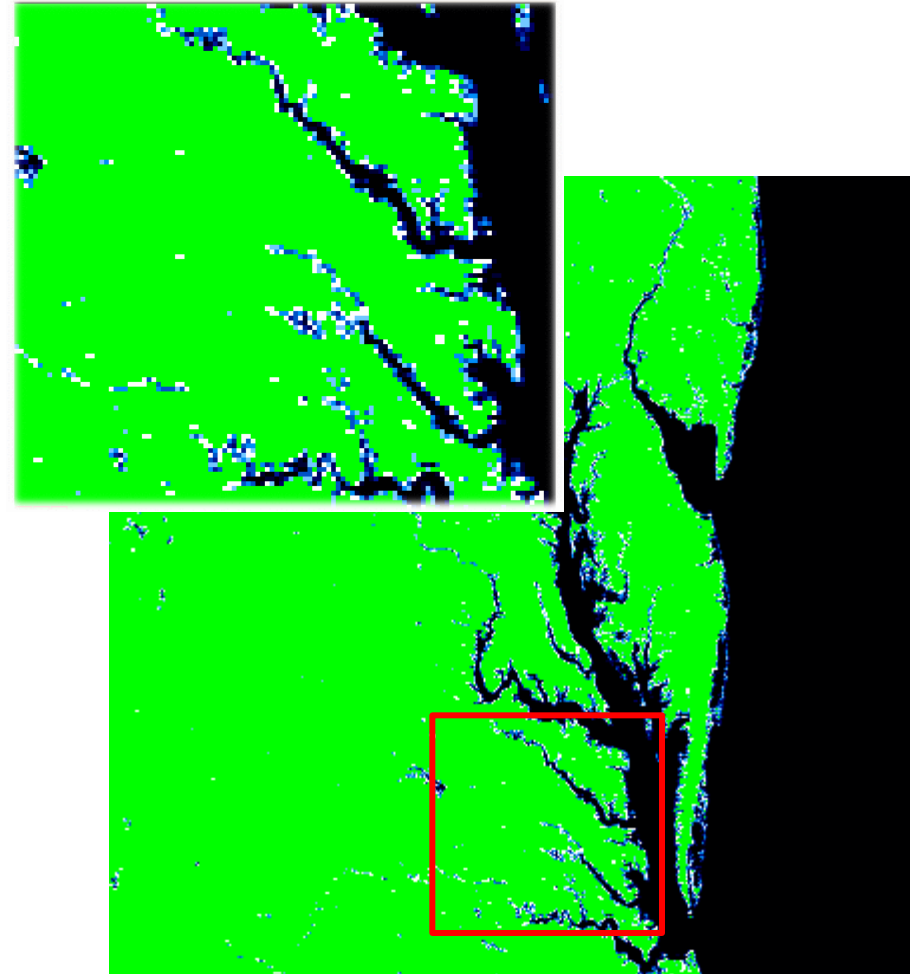
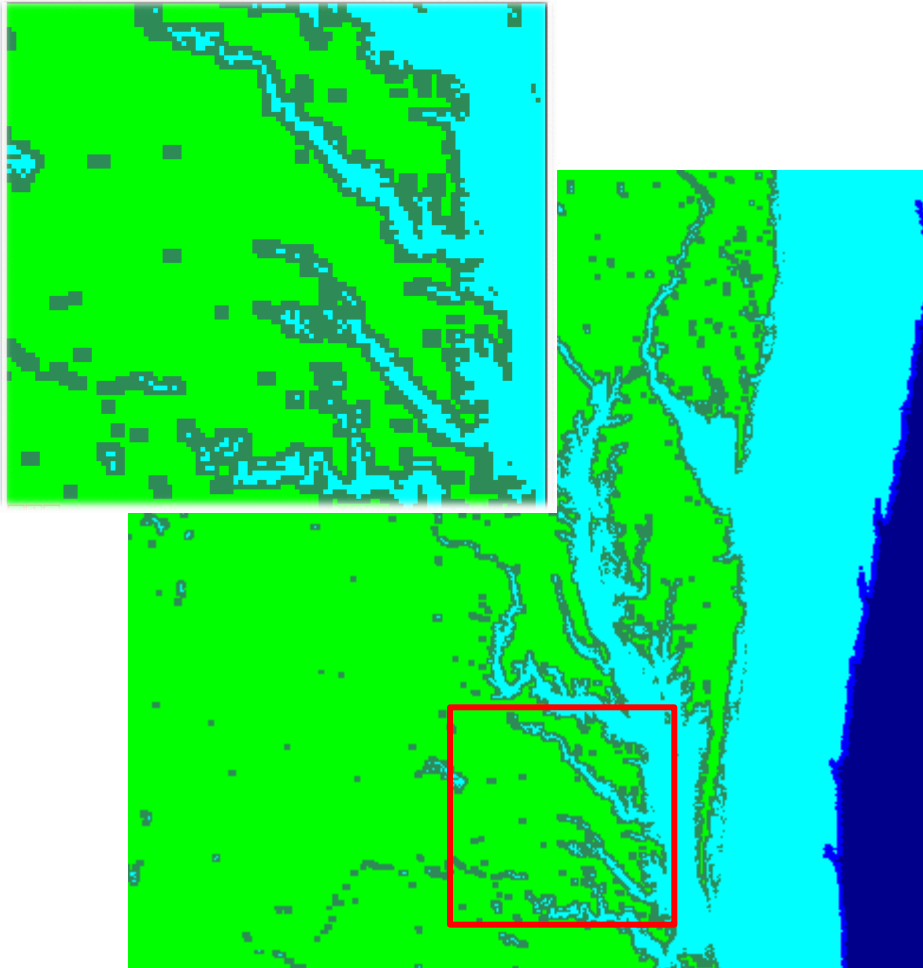
These weights approximate the **triangular** time-integrated weighting function in the **scan** direction and the **rectangular** weighting function in the **track** direction.











New Water Present in C6 MOD03

Land Water Mask

Water Present



- | | | | |
|---|----------------------|---|-------------------|
|  | Shallow Ocean |  | Ephemeral Water |
|  | Land |  | Deep Inland Water |
|  | Coastline/shoreline |  | Moderate Ocean |
|  | Shallow Inland Water |  | Deep Ocean |





C6 Changes - Algorithm (Science)

1. Update error analysis: use C5 residuals to update long-term trend, sun-angle corrections and geometric parameter biases
2. Incorporate new ancillary data
 - a. Improved 500m Shuttle Radar Terrain Mission (SRTM) Digital Elevation Model data
 - b. Improved Land/water mask (500m) developed by UMD
3. Compute 500m geolocation and provide in the form of 8-bit offsets from a bilinear-interpolation of the 1 km data
4. Enhanced 1 km terrain correction (area based)
 - synergistic with 500m geolocation, since weighted average of 500m pixel centers is used to approximate 1km time-integrated weighting function
5. Updated ground control points based on improved GeoCover Landsat 7 products (in conjunction with VIIRS Geolocation activity)



C6 Changes - Other Changes

6. Solar elevation correction (roll, pitch and yaw) written to geolocation product – for transfer to the Control Point Residual files
7. Added scan metadata reporting the quality and type of the ephemeris/attitude data used in the calculations
8. For some users (DB and Oceans): Added file level metadata indicating whether or not terrain correction was performed. (*Terrain correction is always used in MODAPS.*)
9. For DB users: Correct the setting of *attitQuat* when ephemeris source is "MODIS Packet". When that source is used, the *attitQuat* is currently set to a constant value indicating nominal orientation (roll, pitch, and yaw are all zero). *attitQuat* is used only in the calculation of the solar "elevation" angle correction.



Questions?