MODIS Geolocation Status

MODIS Science Team Meeting
Calibration Breakout Session

April 17, 2013

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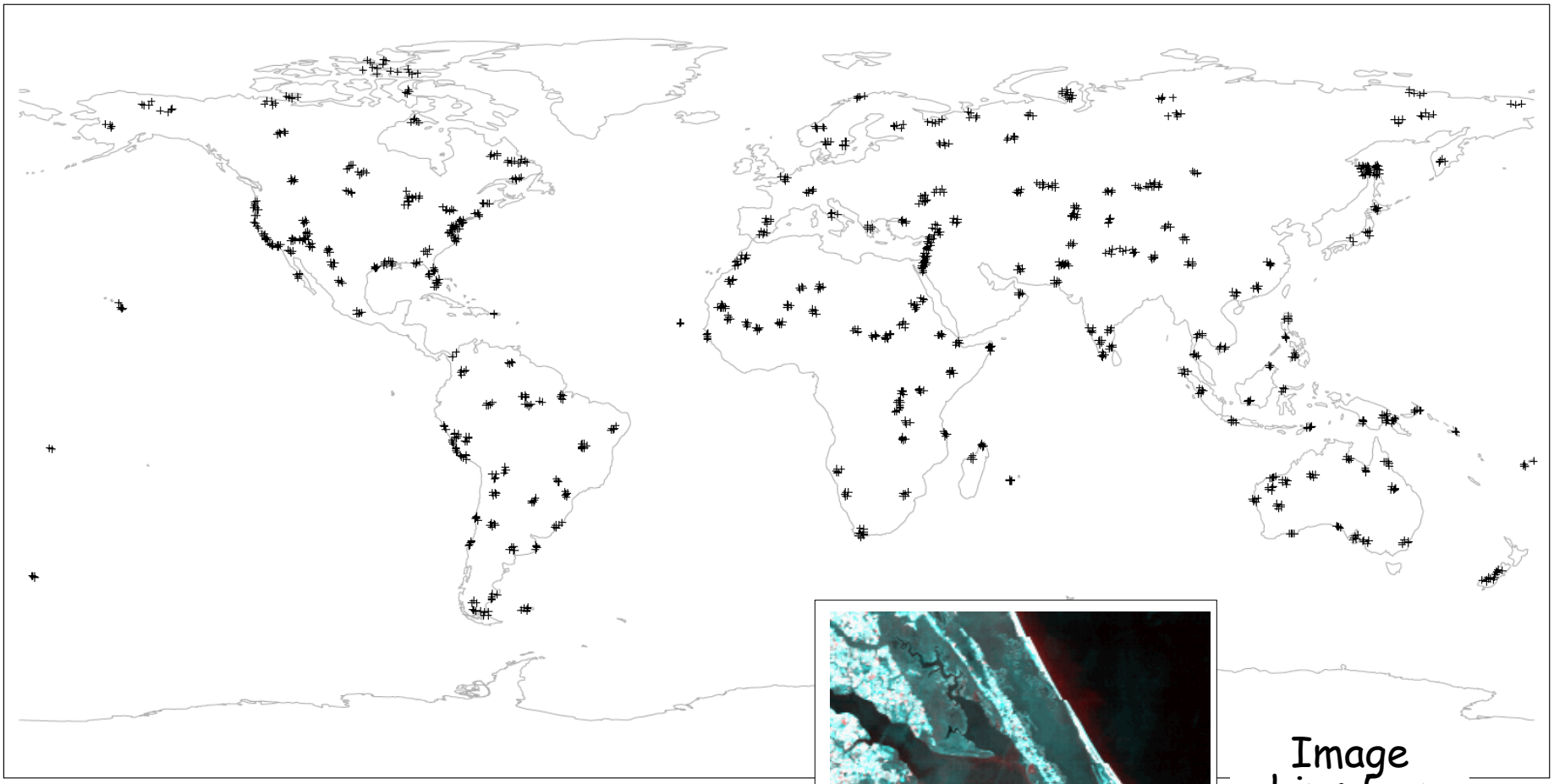
MODIS Geolocation Team

NASA GSFC Code 619

Ground Control Points (GCPs)



1214 GCPs

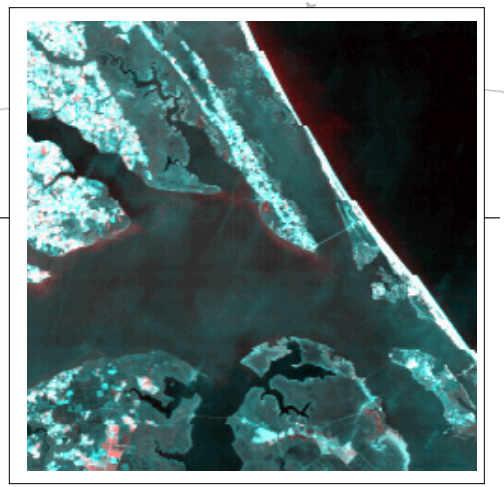


Image chips from Landsat TM/ETM scenes

Geolocation C5/C6 results

Terra

- Excellent results –Root Mean Square Error (RMSE) in nadir equivalent units is better than accuracy goal
- Large errors occur ~1.5 hr after maneuvers (about 12 per year)
  - accuracy in following orbit suspect

Aqua

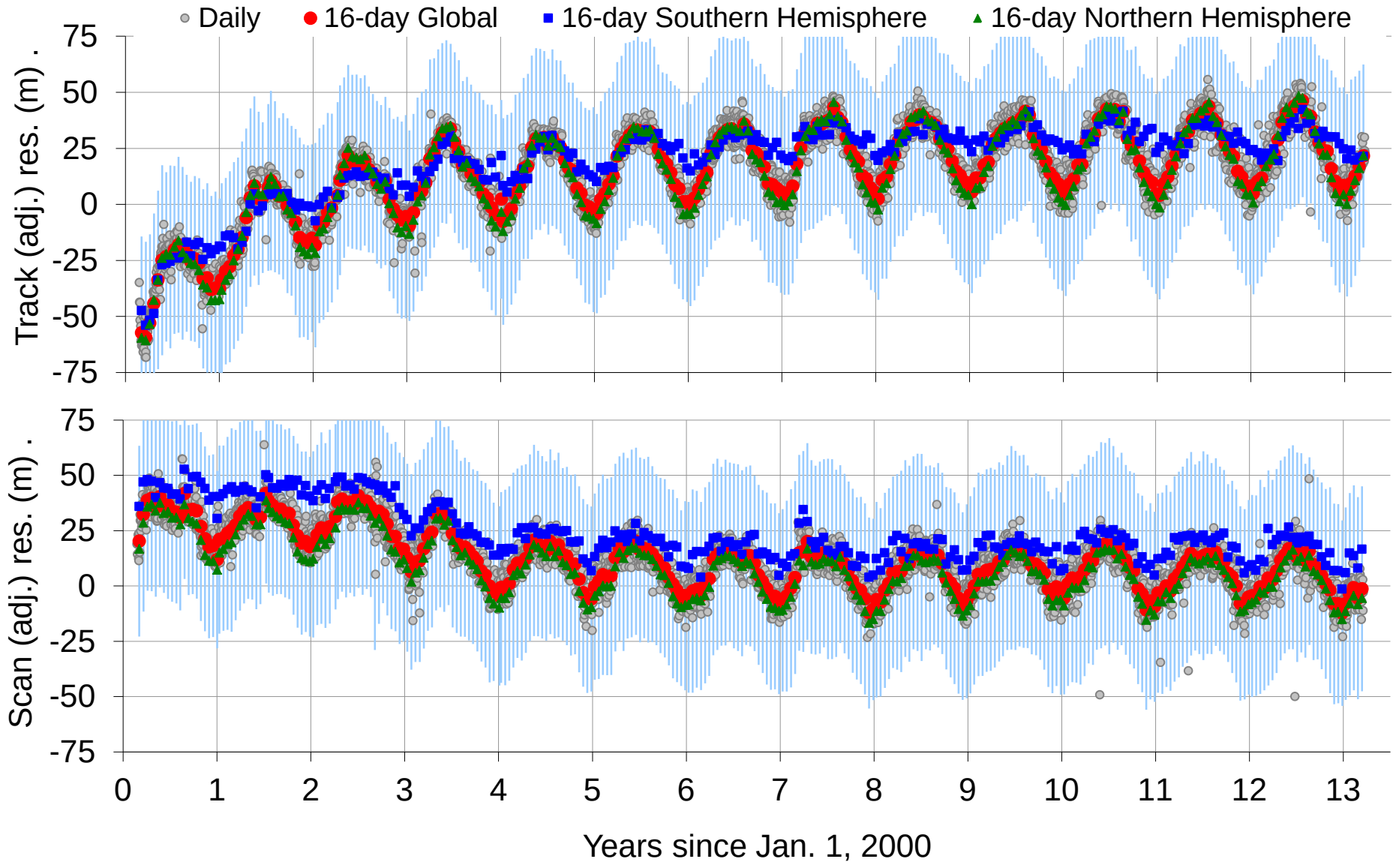
- Good results – RMSE is better than goal in track direction but slightly over goal in scan direction (but much better than specification – 150 m)
- Definitive ephemeris is used for best results – causes up to 24 hr processing delay

	Terra		Aqua	
	C5	**C6**	**C5**	**C6**
Along-track RMSE (m)	43	42	48	46
Along-scan RMSE (m)	44	42	53	51
Years of Data	13.1		10.7	
Ground Control Point Match-ups/day	263		227	

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.

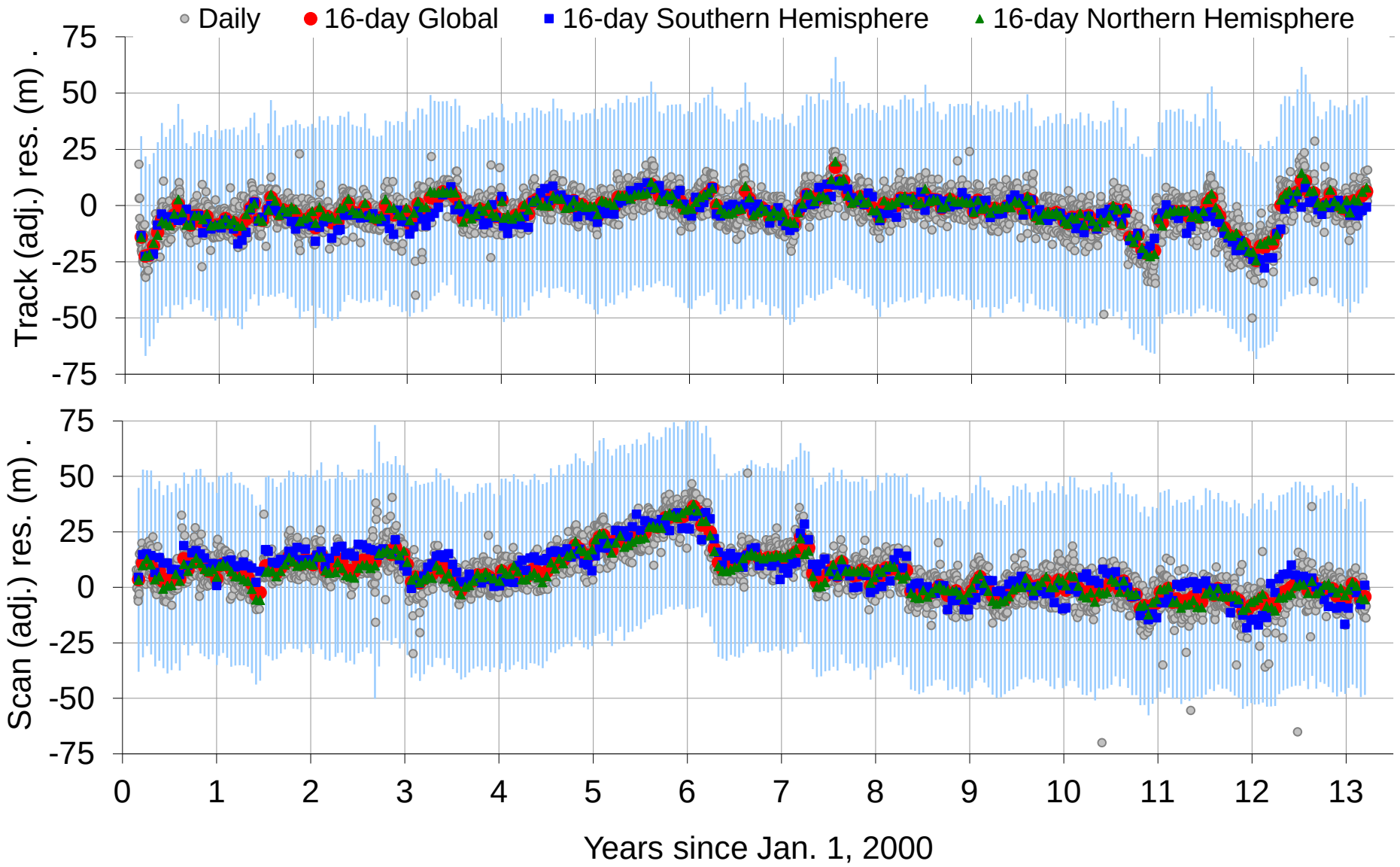
Terra trend and update details

Terra long-term trend (w/o correction)



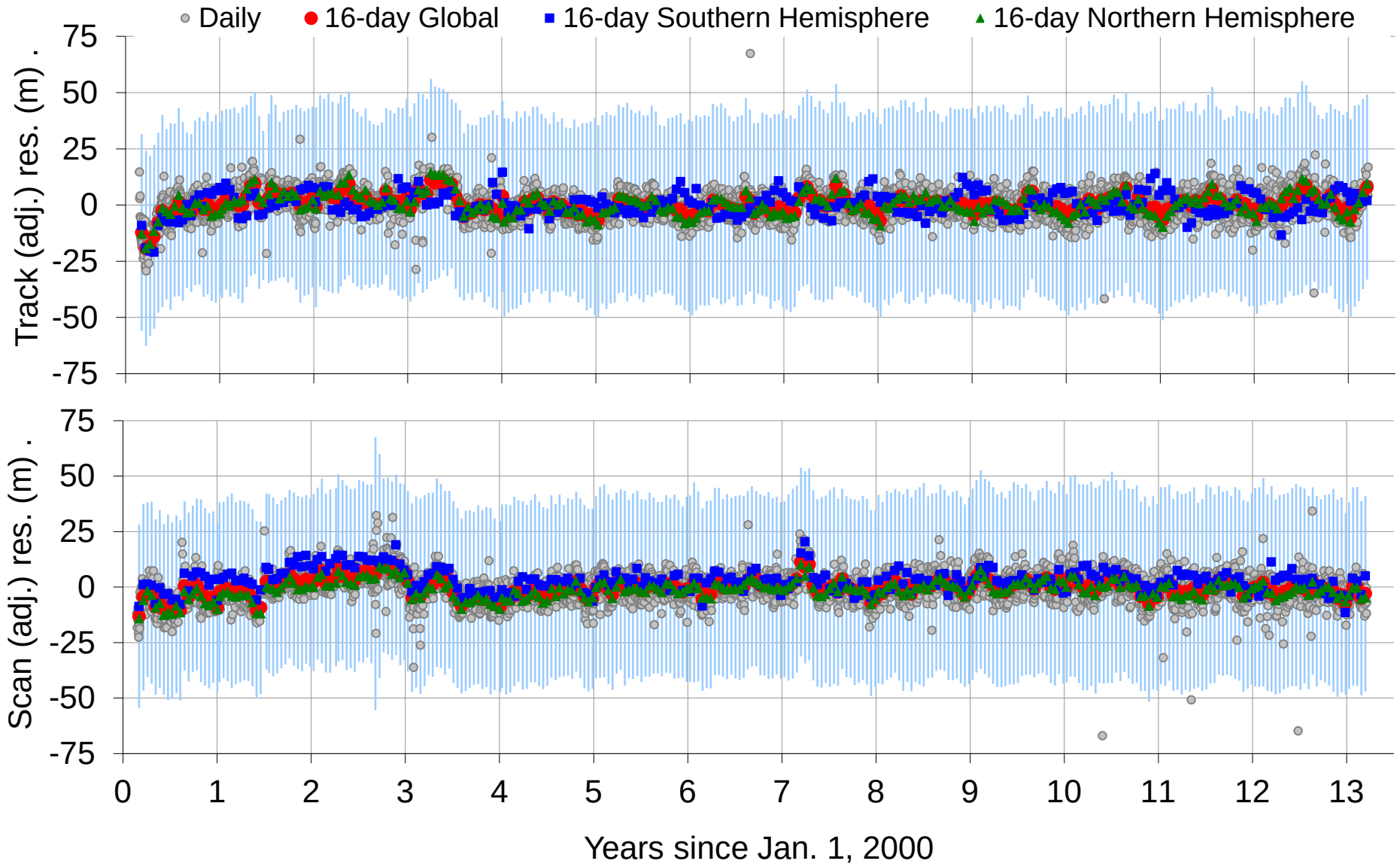
RMSE with no correction: Track: 49 m (+7 m vs C6) Scan: 47 m (+5 m vs C6)

Actual Terra C5 residuals



C5 RMSE Track: 43 m Scan: 44 m

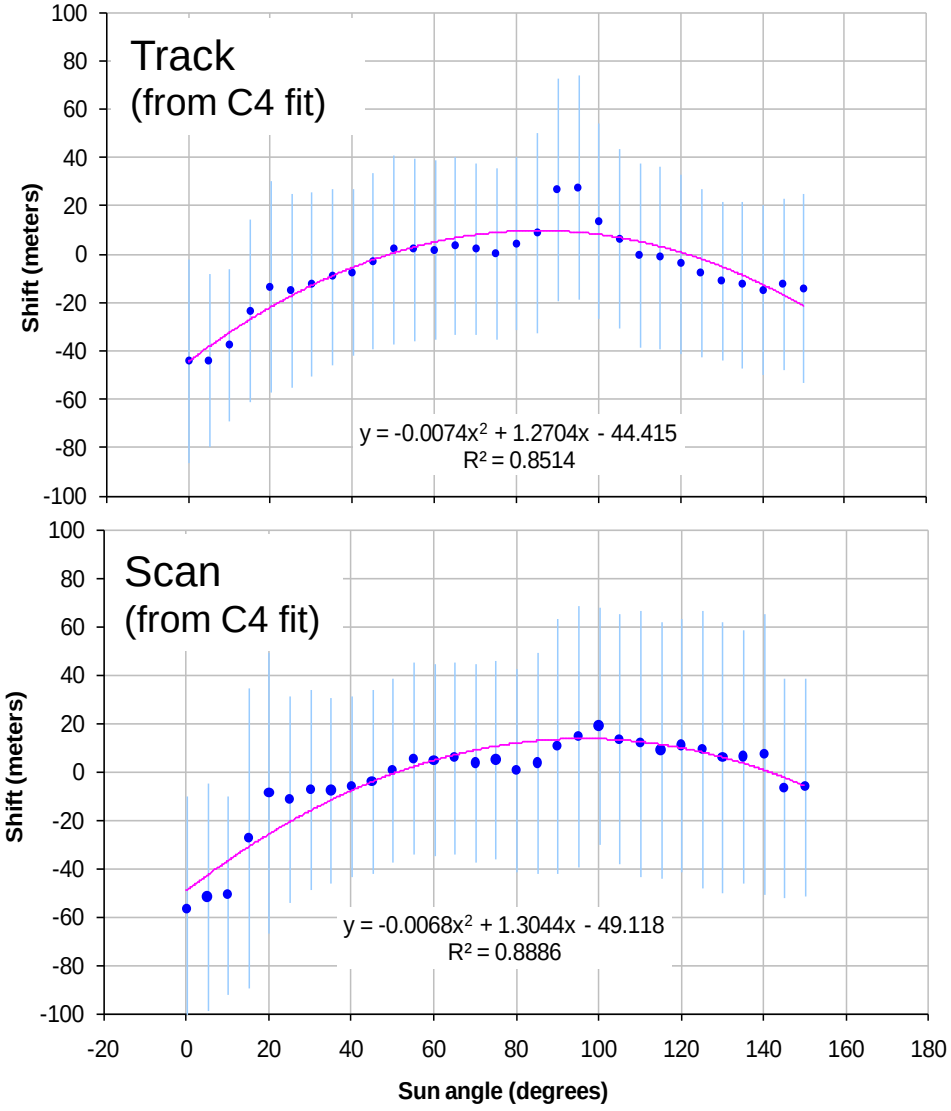
Terra C6 residuals (estimated)



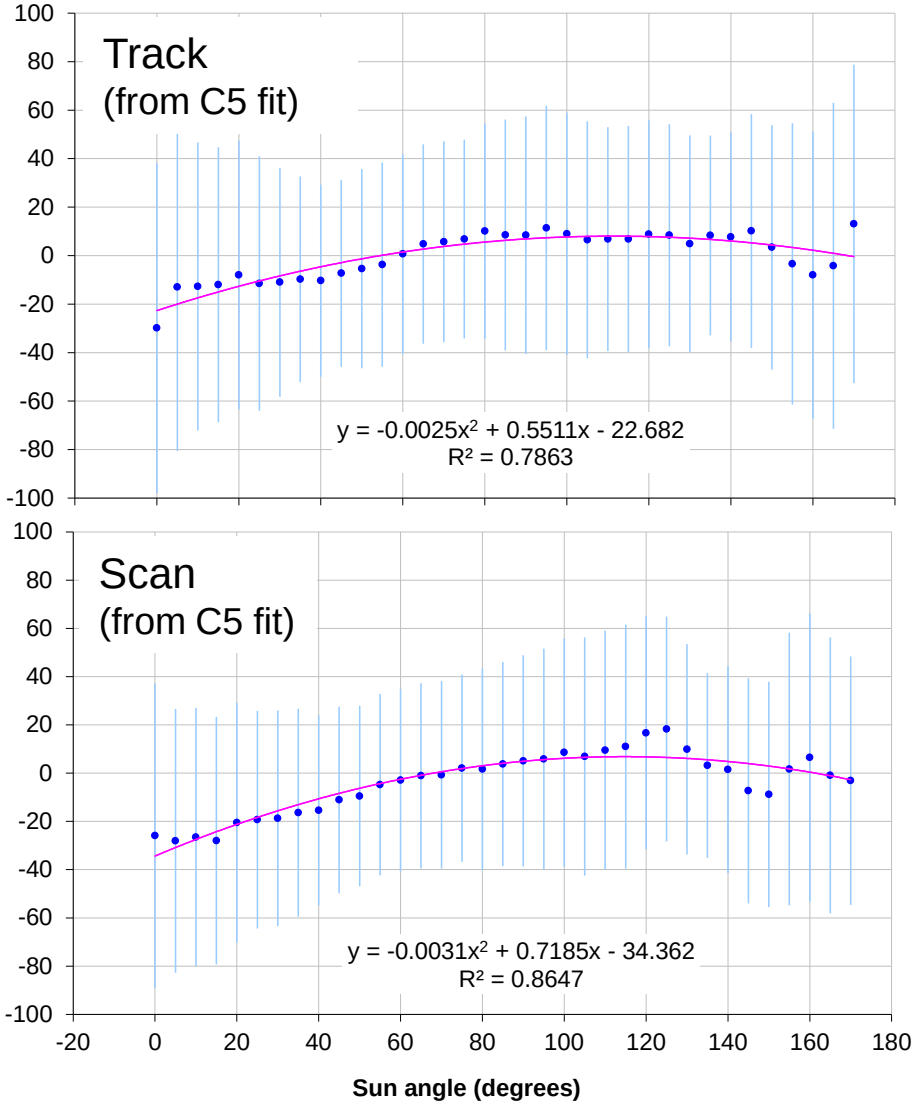
C6 RMSE Track: 42 m (-1 m vs C5) Scan: 42 m (-2 m vs C5)

Terra Sun angle Correction

Used in C5



Used in C6



Small overcorrection in C5 – was corrected in C6

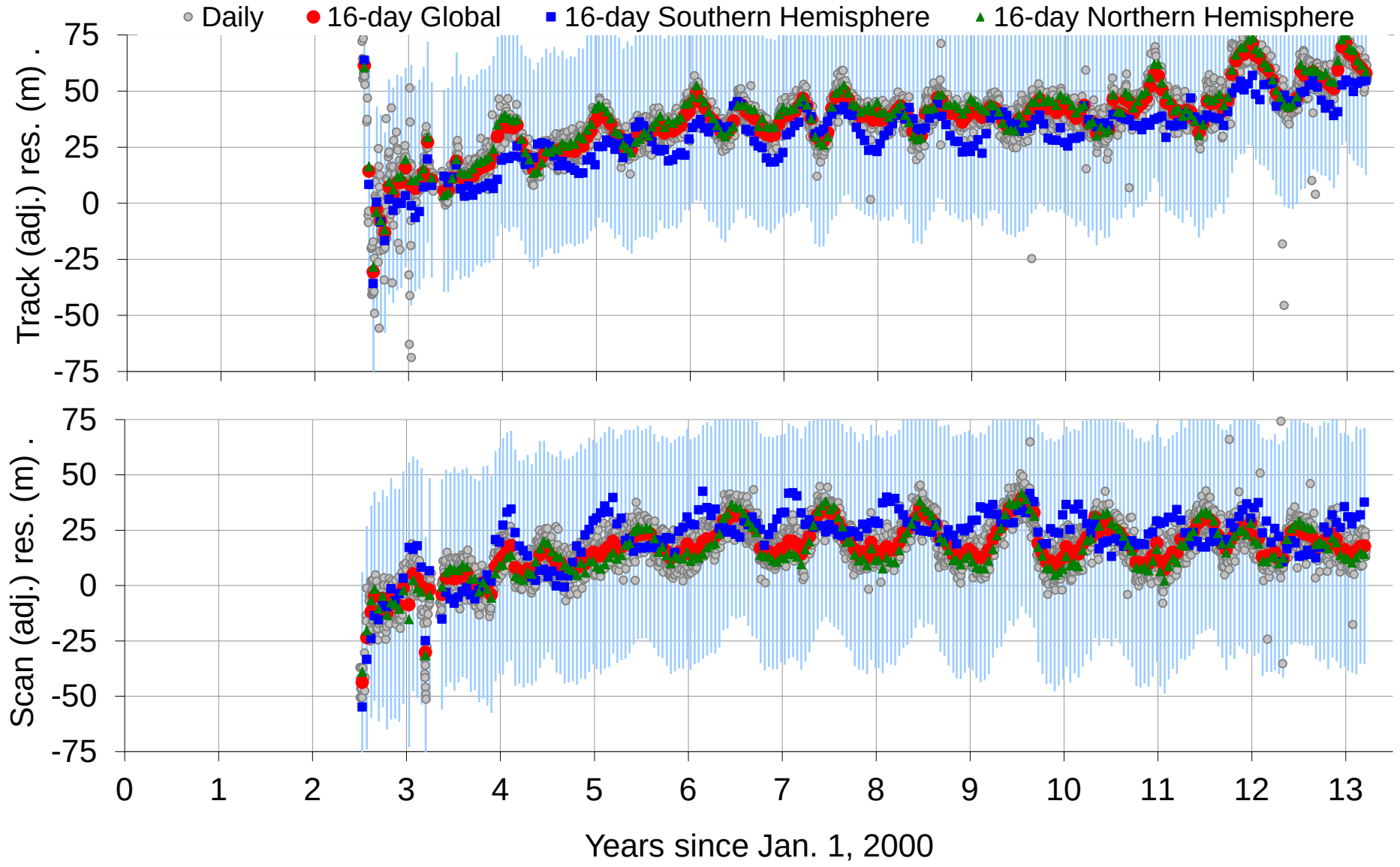
Terra C6 geometric parameter changes

- 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 333.333 μsec)

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)	μsec	0.0	3.1	3.1

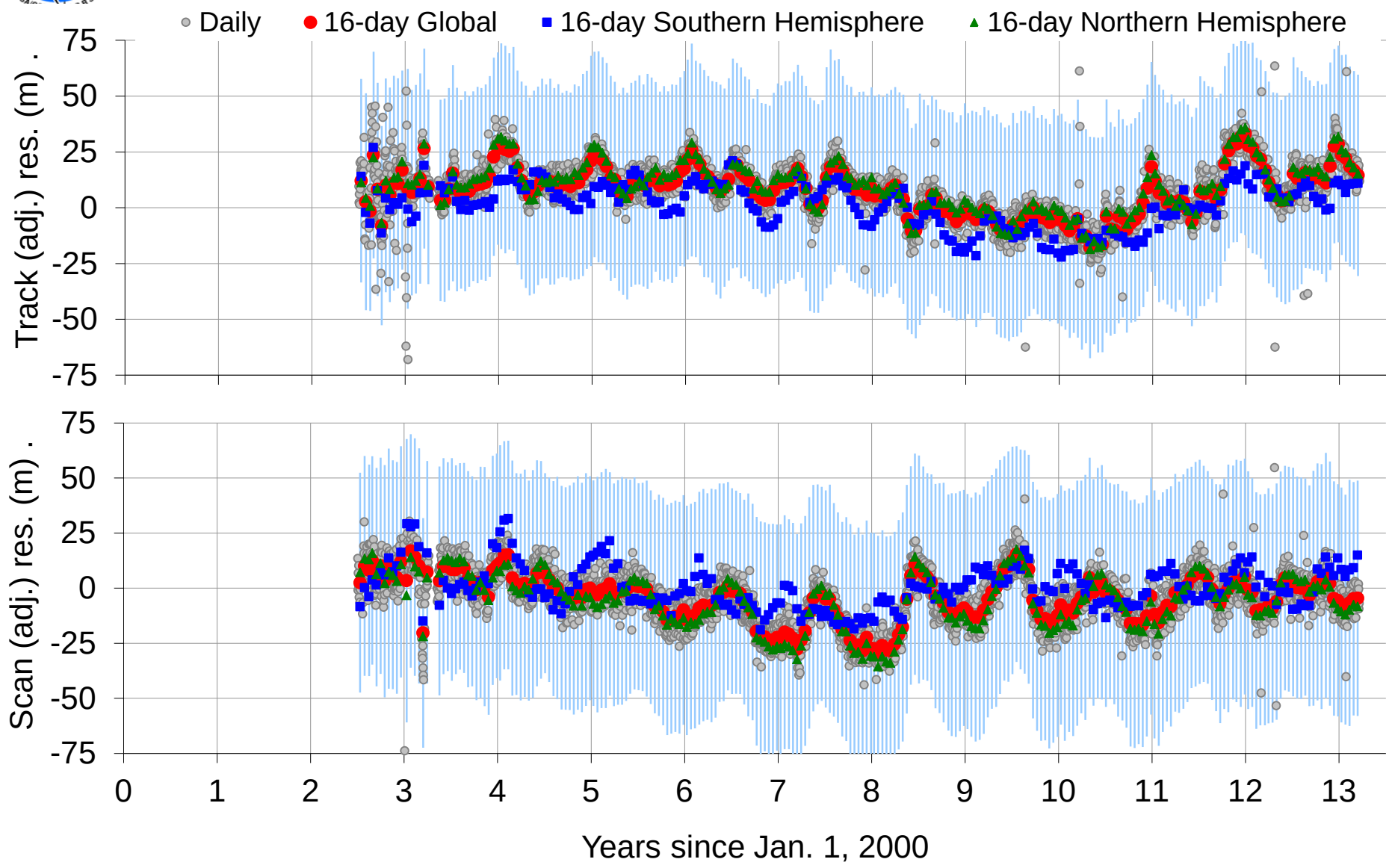
Aqua trend and update details

Aqua Long-term Trend (w/o Correction)



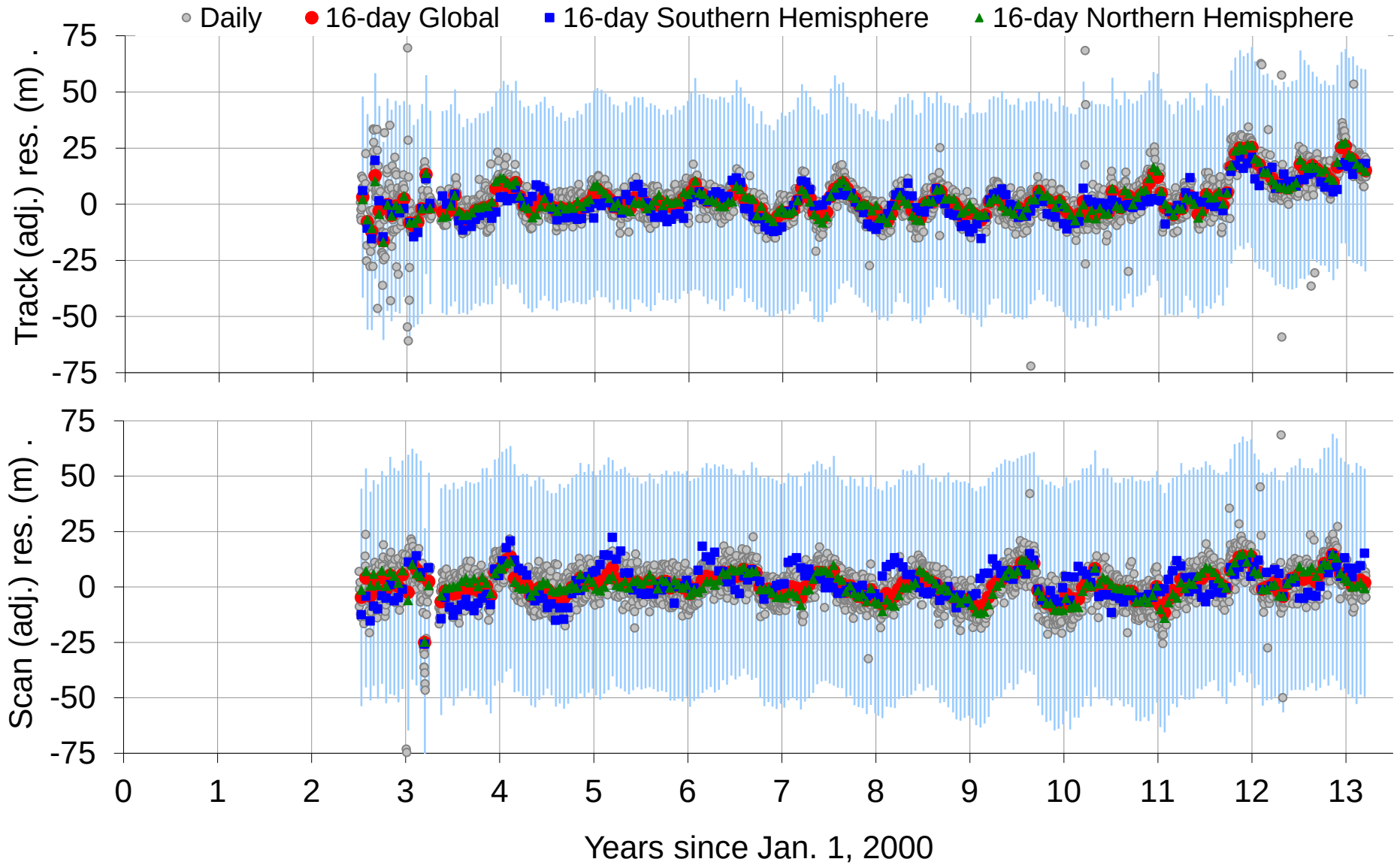
RMSE with no correction: Track: 60 m (+15 m vs C6) Scan: 56 m (+5 m vs C6)

Actual Aqua C5 residuals



C5 RMSE Track: 48 m Scan: 53 m

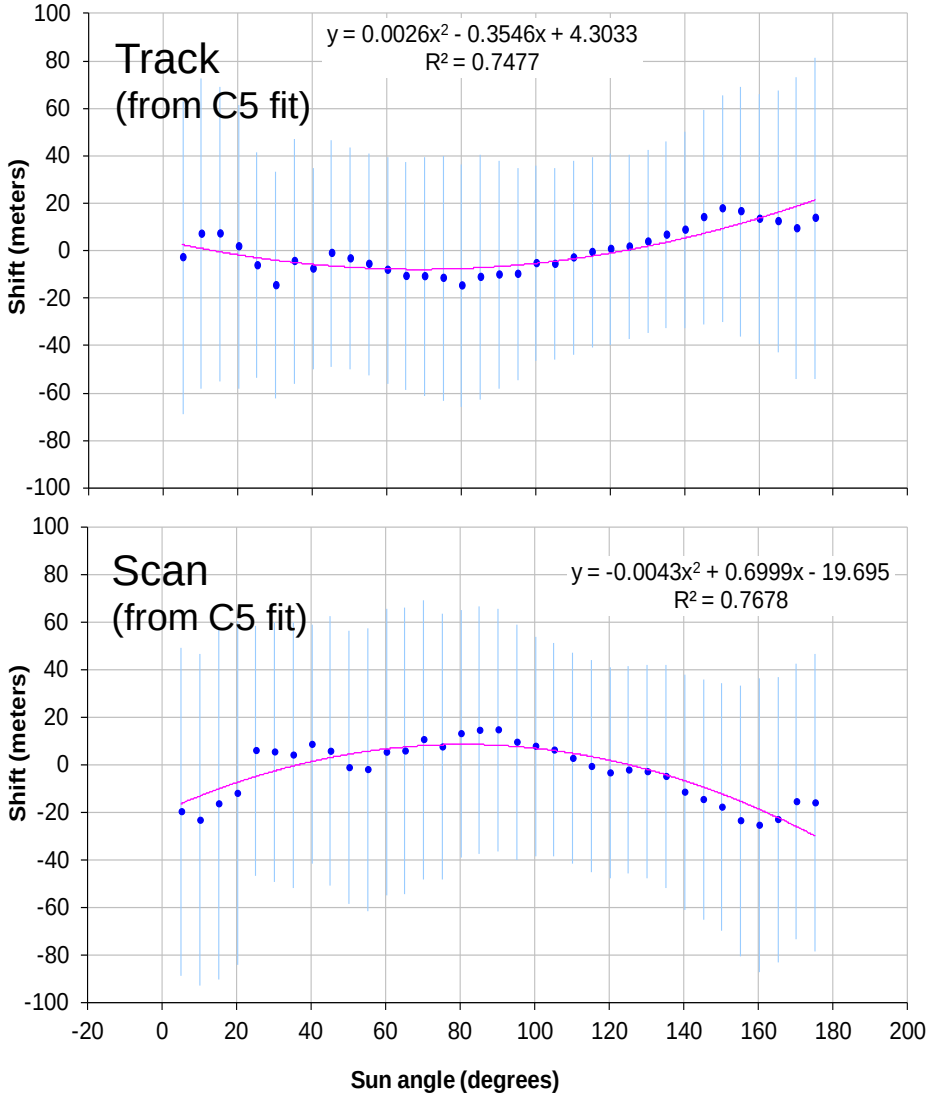
Aqua C6 residuals (estimated)



C6 RMSE Track: 46 m (-2 m vs C5) Scan: 51 m (-2 m vs C5)

Aqua Sun angle Correction

Track and Scan sun-angle effects
- no correction in C5
- used in C6



Aqua C6 geometric parameter changes

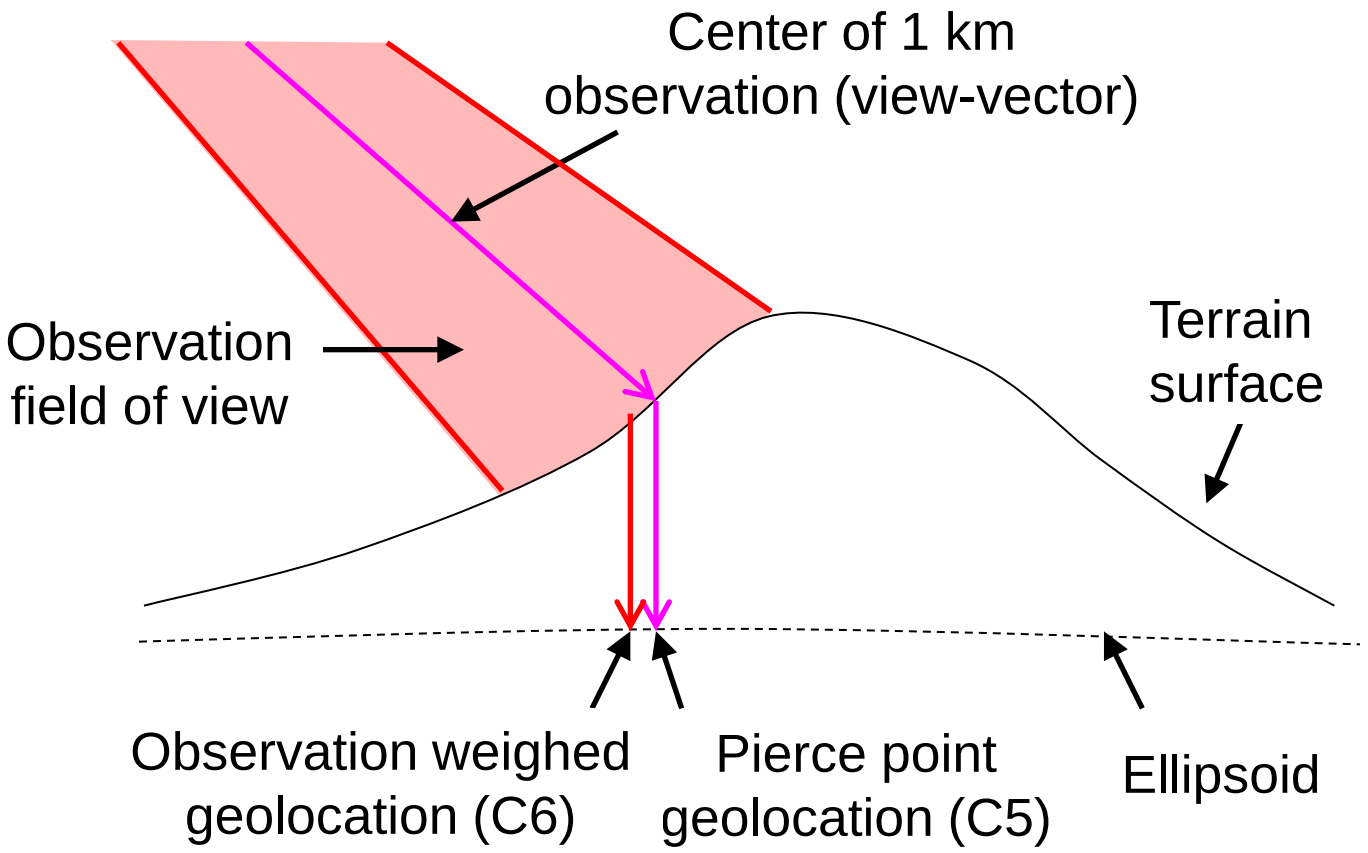
- Change in geometric biases and scan mirror rate
  - Based on global hierarchical maximum decent search
  - Small changes to telescope tilt and mirror parameters (alpha, beta and gamma)
  - Sample time bias (delta added to nominal 333.333 μsec)

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)	μsec	0.0	6.6	6.6

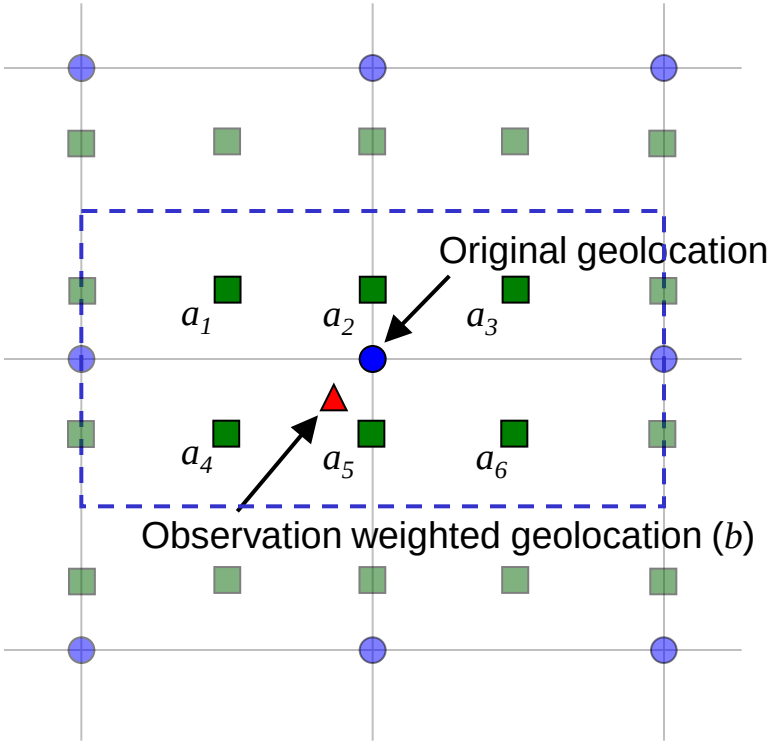
C6 Changes – Algorithm (Science)

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

C6 observation weighted terrain correction



Observation weighted terrain correction



– Original 1km geolocation

– 500m geolocation

– Observation weighted geolocation

a_1 to a_6 and b are geocentric cartesian coordinates (x, y, z)

Scan direction

Track direction

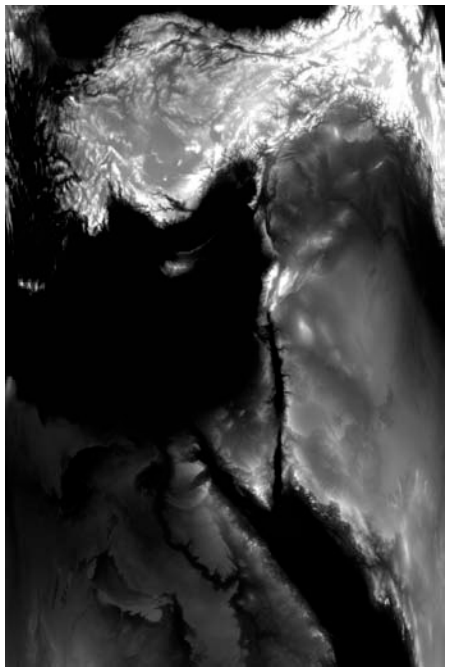
The first order approximation of the observation weighted point is:

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

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.

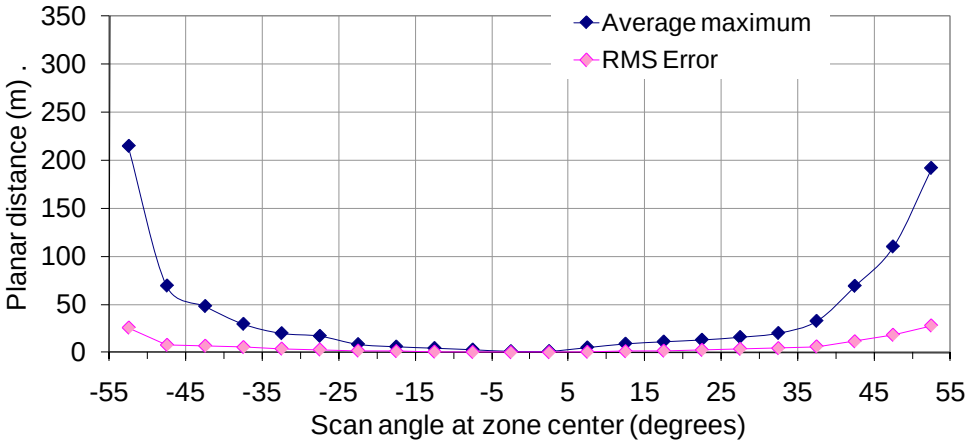
Example: Terra – Middle east

2001/199.0840



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

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



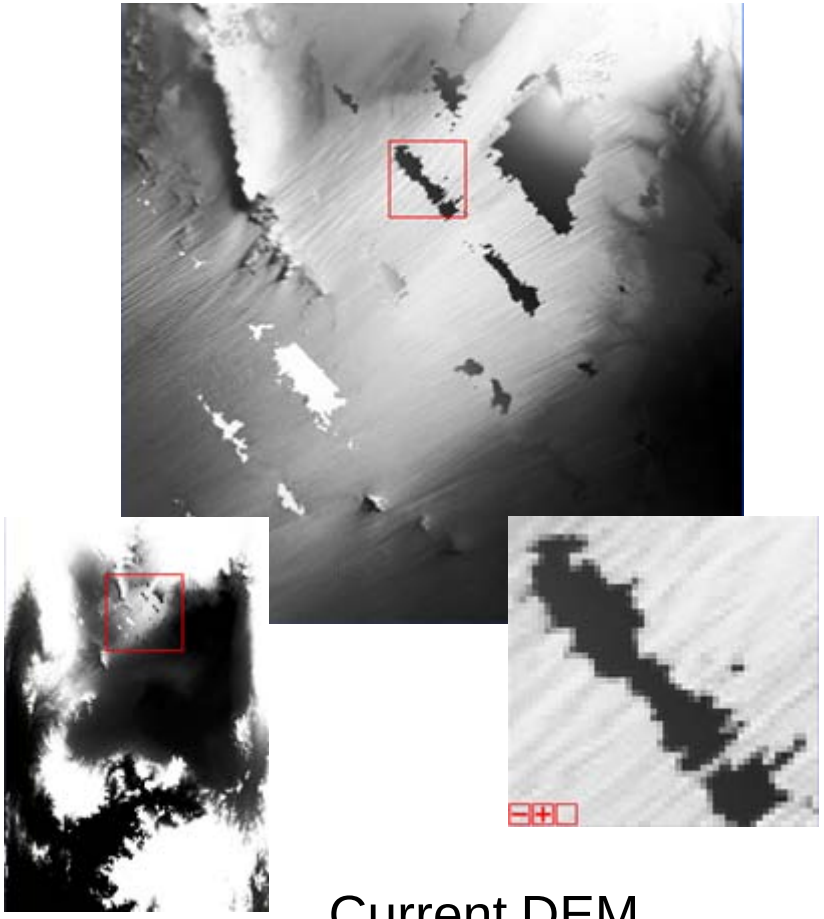
New for C6: 500m geolocation (pierce point) is also available, stored as offsets from 1km geolocation (observation weighed)

New C6 DEM

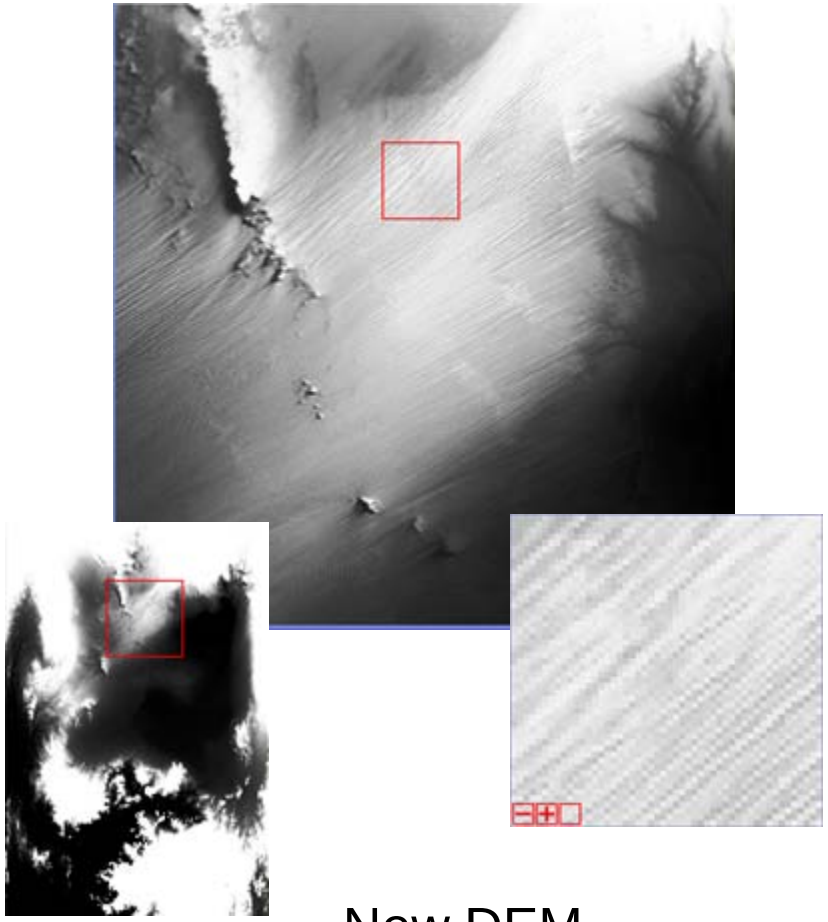
- Current C5 DEM
  - SRTM based gap filled
  - Uncertain about the heritage of the approach to reducing resolution and gap filling
  - Only available at 30 arc-sec (~1km) DEM
- New C6 DEM (Source: USGS and NGA, Danielson et al.)
  - Being used at 15 arc-sec (~500m)
  - Better data is now available for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

Old vs. New DEM

MODIS Geolocation Height (data-day 2010/221)



Current DEM
(C5)

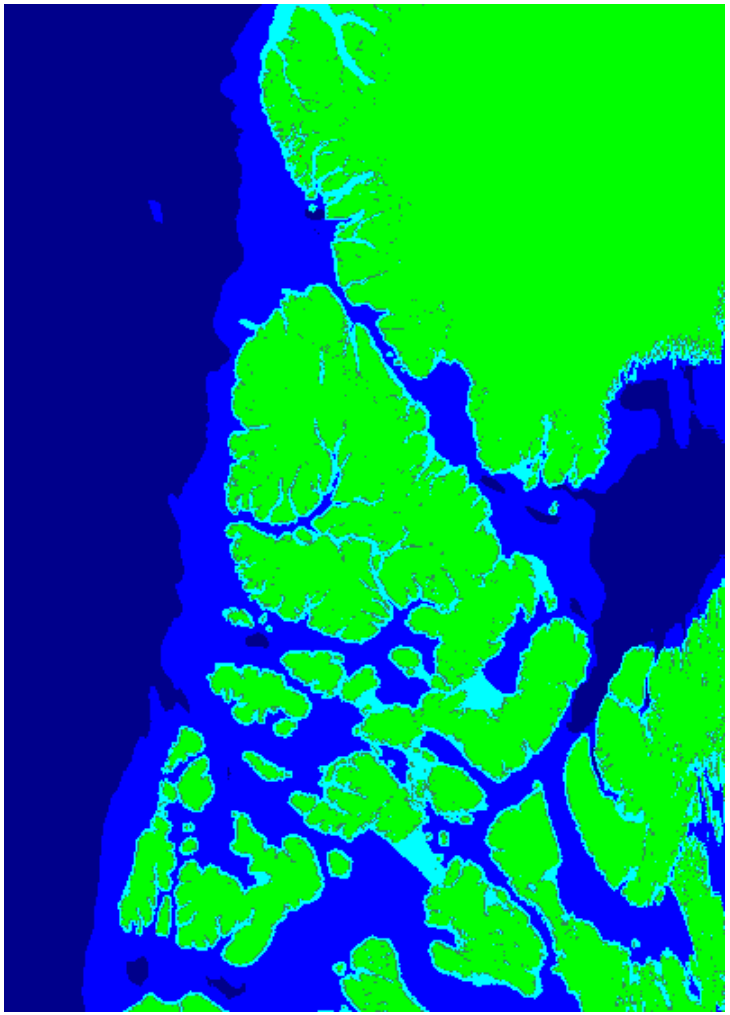


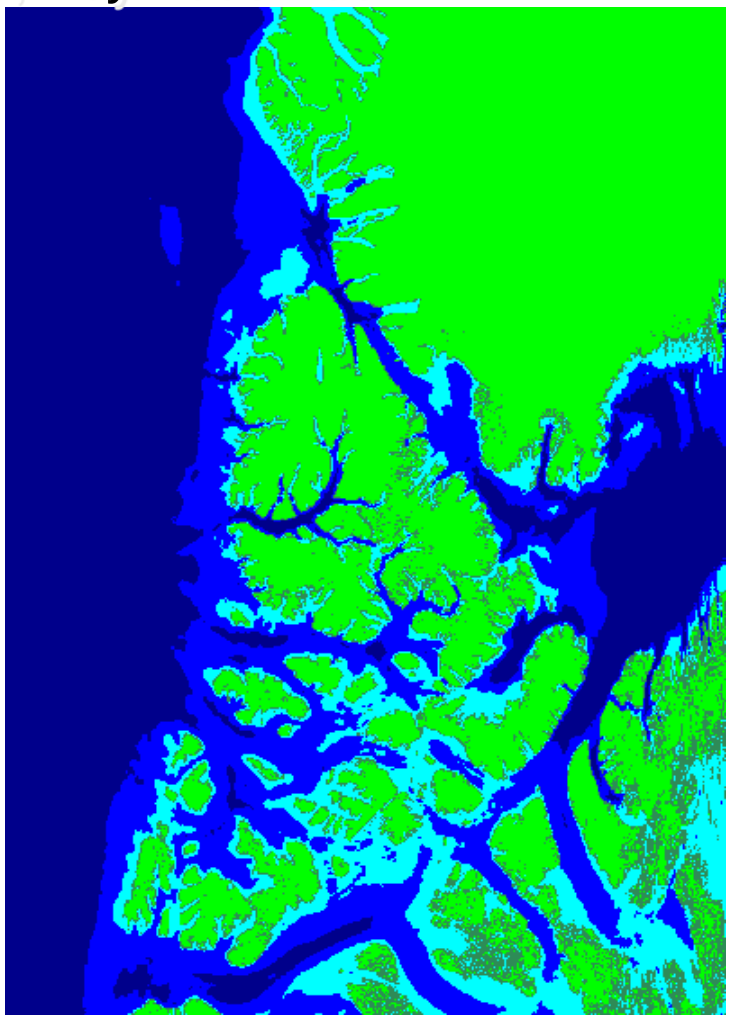
New DEM
(C6)

New Land Water Mask in C6 MOD03

Terra Granule 19:25, Day 2003-193

C5



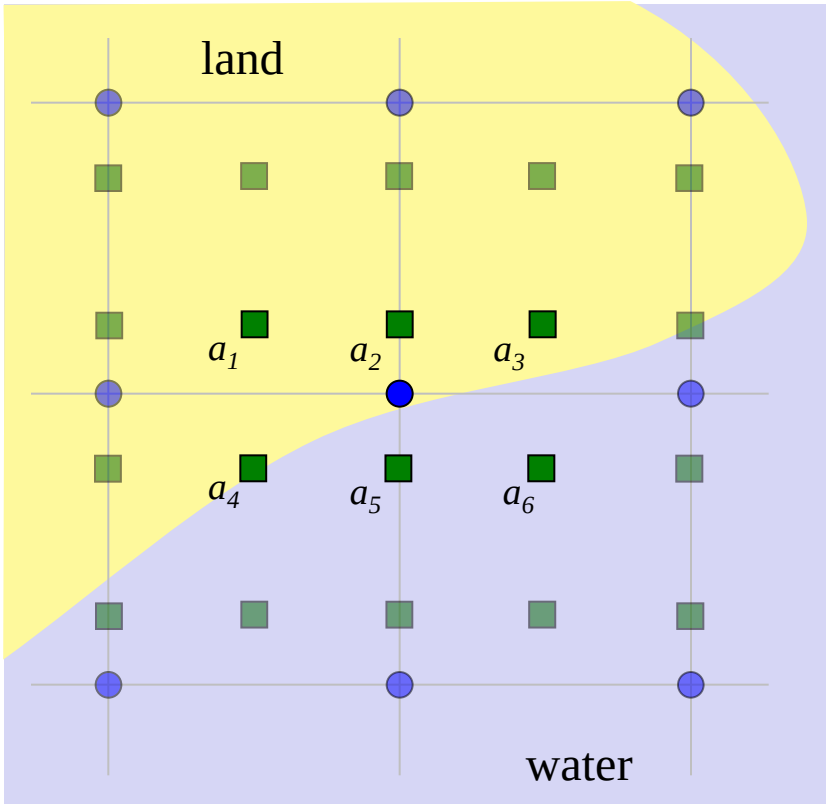


C6

Shallow Ocean
Land
Coastline/shoreline
Shallow Inland Water

Ephemeral Water
Deep Inland Water
Moderate Ocean
Deep Ocean

Water present method at 1km



Scan direction

Track direction

– 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

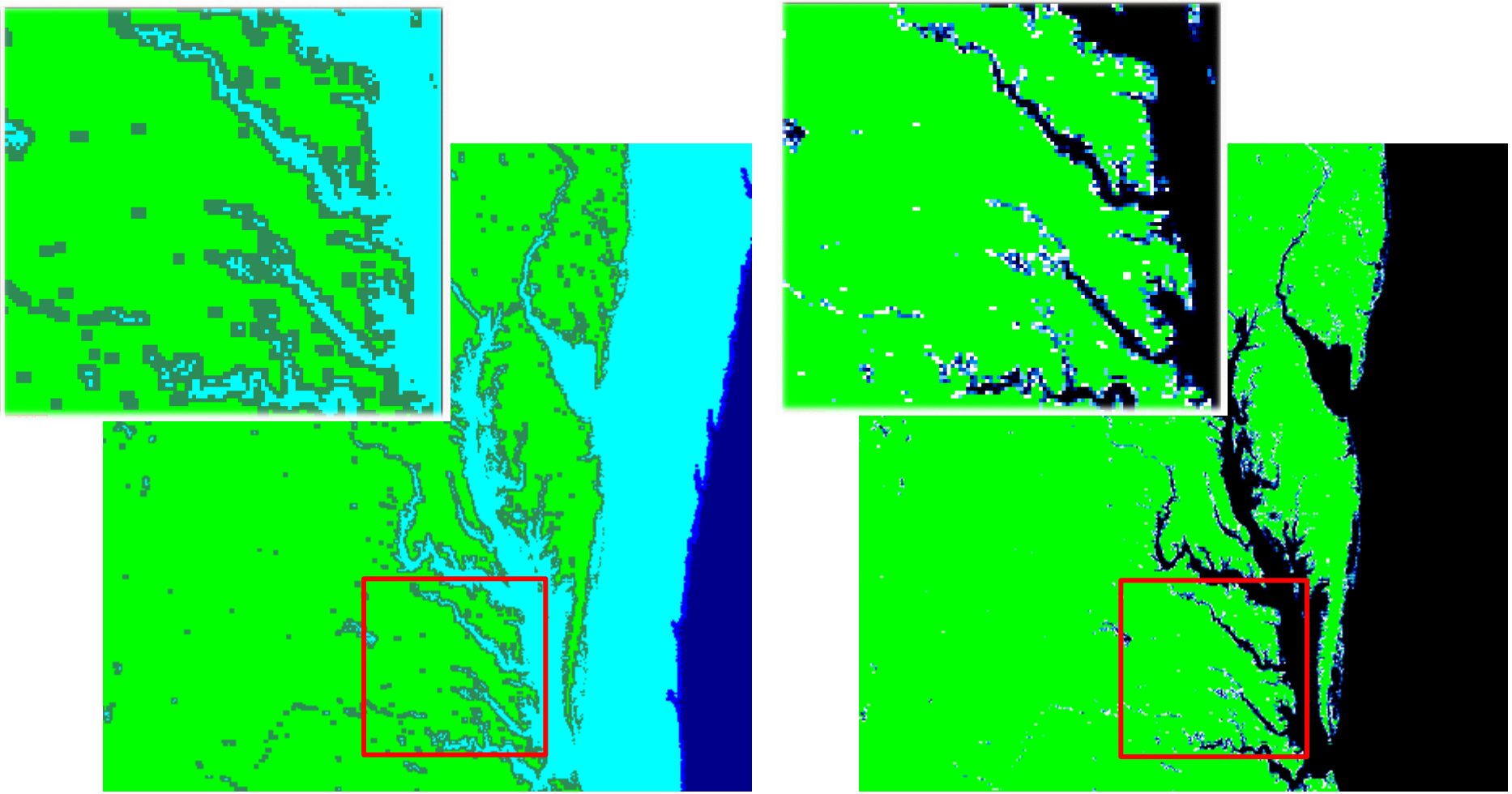
$$b = (a_1 + a_3 + a_4 + a_6) + 2\,(a_2 + a_5)$$

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
Land
Coastline/shoreline
Shallow Inland Water

Ephemeral Water
Deep Inland Water
Moderate Ocean
Deep Ocean

1 8

Terra granule subset 2003/193 16:20

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)

Questions?

C6 Changes – Other Changes

1. Solar elevation correction (roll, pitch and yaw) written to geolocation product – for transfer to the Control Point Residual files
2. Added scan metadata reporting the quality and type of the ephemeris/attitude data used in the calculations
3. 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.)*
4. 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.