MODIS Geolocation Status

MODIS/VIIRS ST Meeting
Calibration Breakout Session

January 25, 2010

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MODIS Geolocation Team

NASA GSFC Code 614.5

Geolocation C5 results

Terra

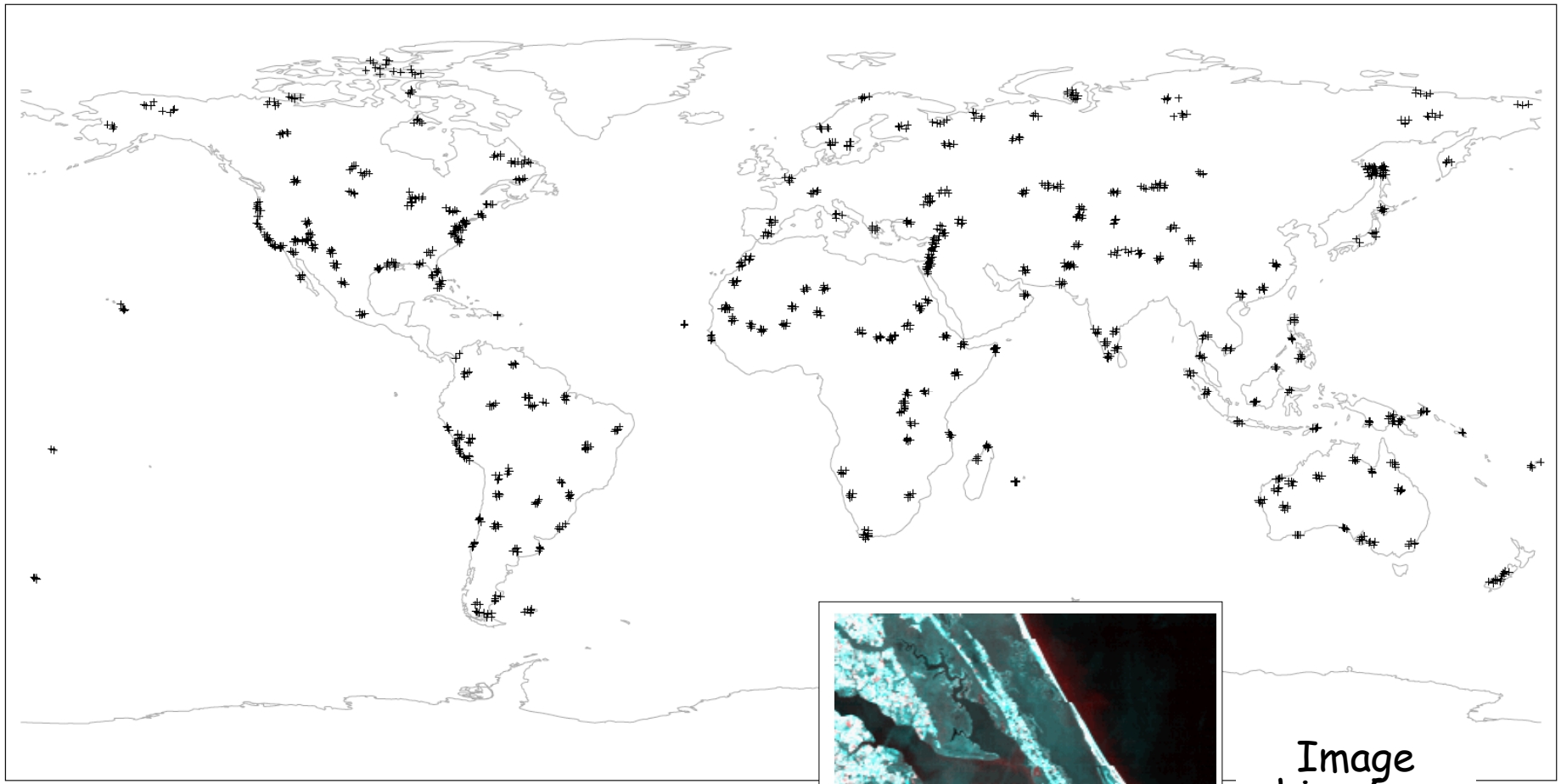
- Excellent results – C5 Root Mean Square (RMS) error in nadir equivalent units is better than accuracy goal
- Sun angle fit corrects for most of northern/southern hemisphere differences
- Large errors occur after maneuvers (about 12 per year)
  - accuracy in following orbit suspect

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	47
Along-scan RMS error (m)	44	53
Years of Data	9.9	7.5
Ground Control Point Match-ups/day	268	231

Ground Control Points (GCPs)



1214 GCPs used in C5

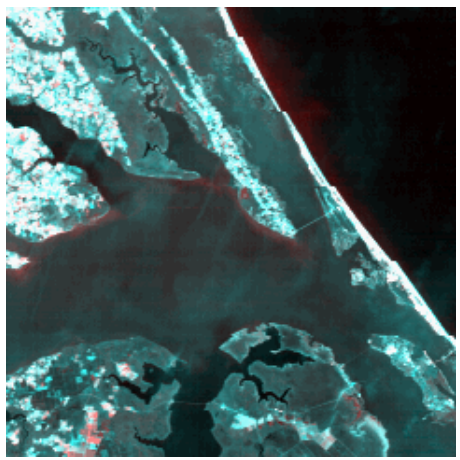
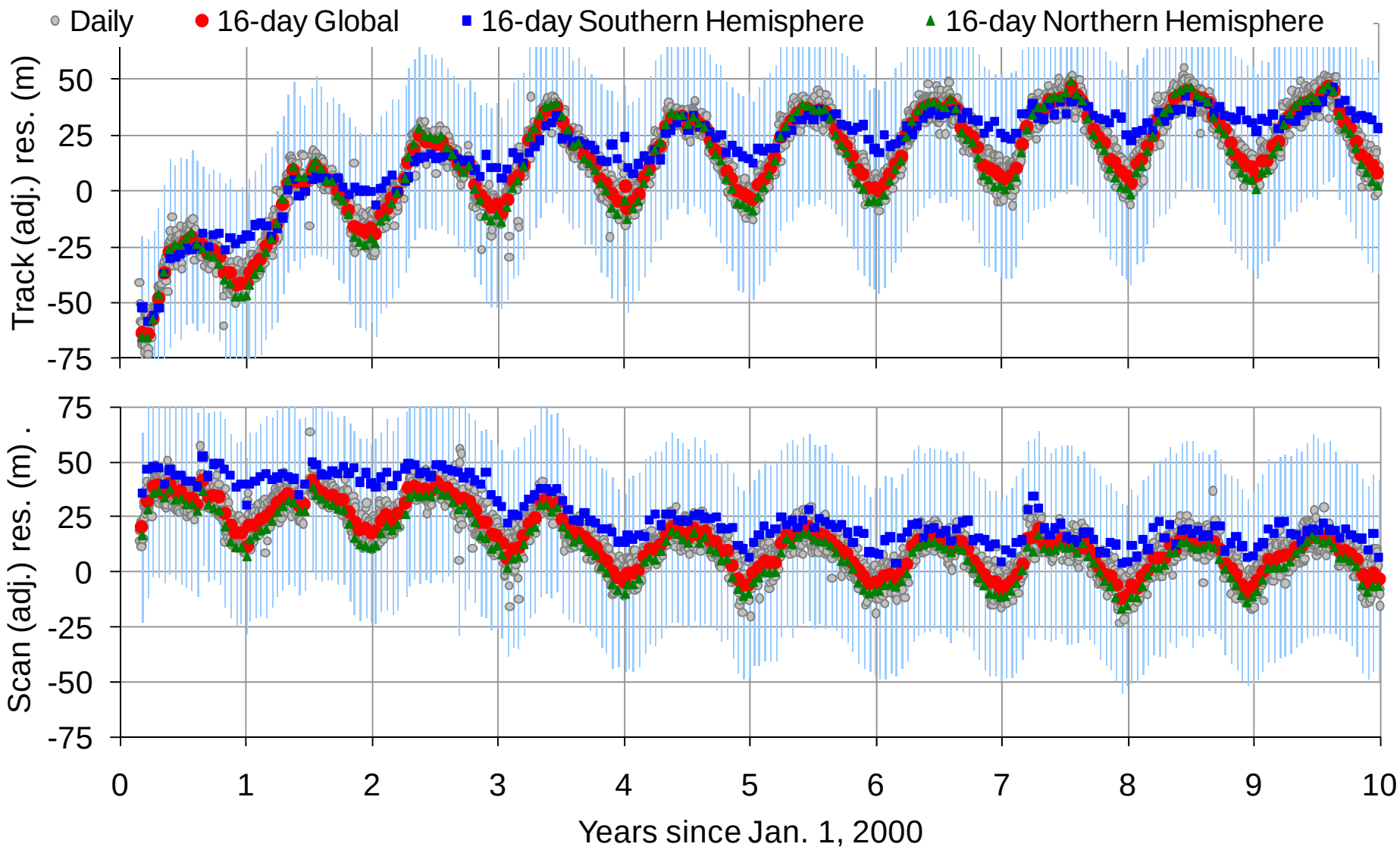


Image chips from Landsat TM/ETM scenes

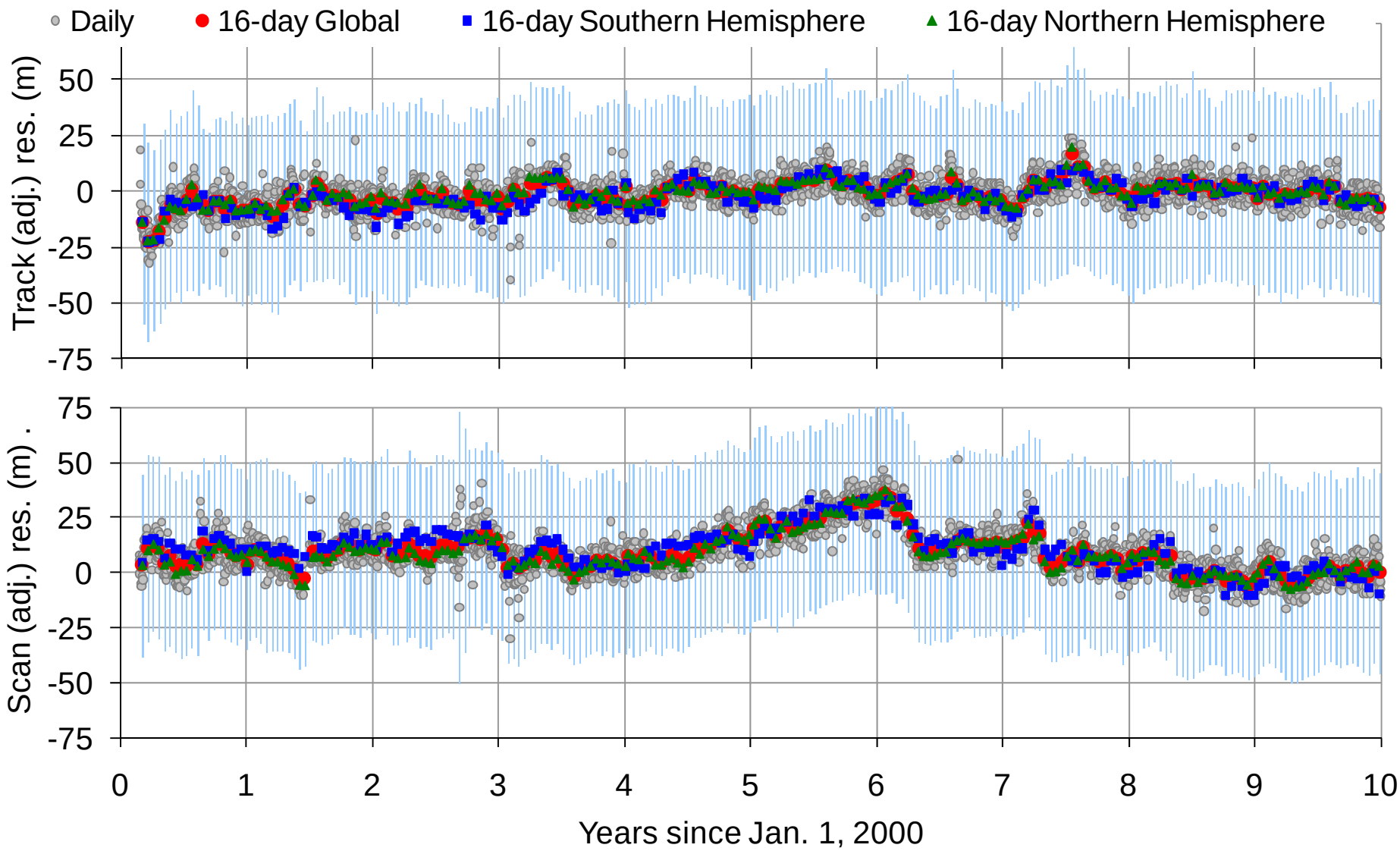
Terra Long-term Trend Details

Terra Long-term Trend (w/o Correction)



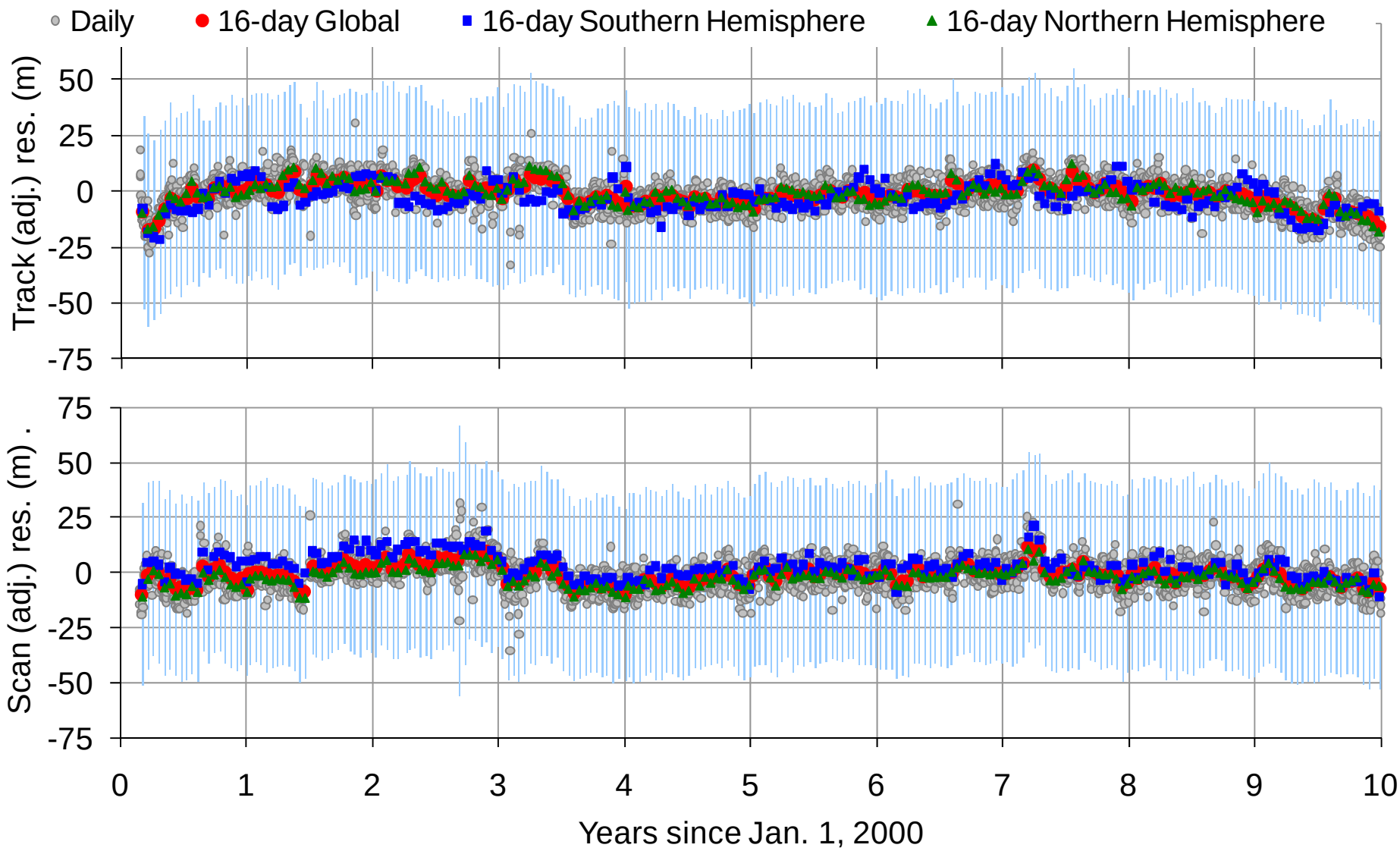
Track RMS: 50m (+7m vs C5) Scan RMS: 47m (+3m vs C5)

Actual Terra C5 residuals



Track RMS: 43m (C5) Scan RMS: 44m (C5)

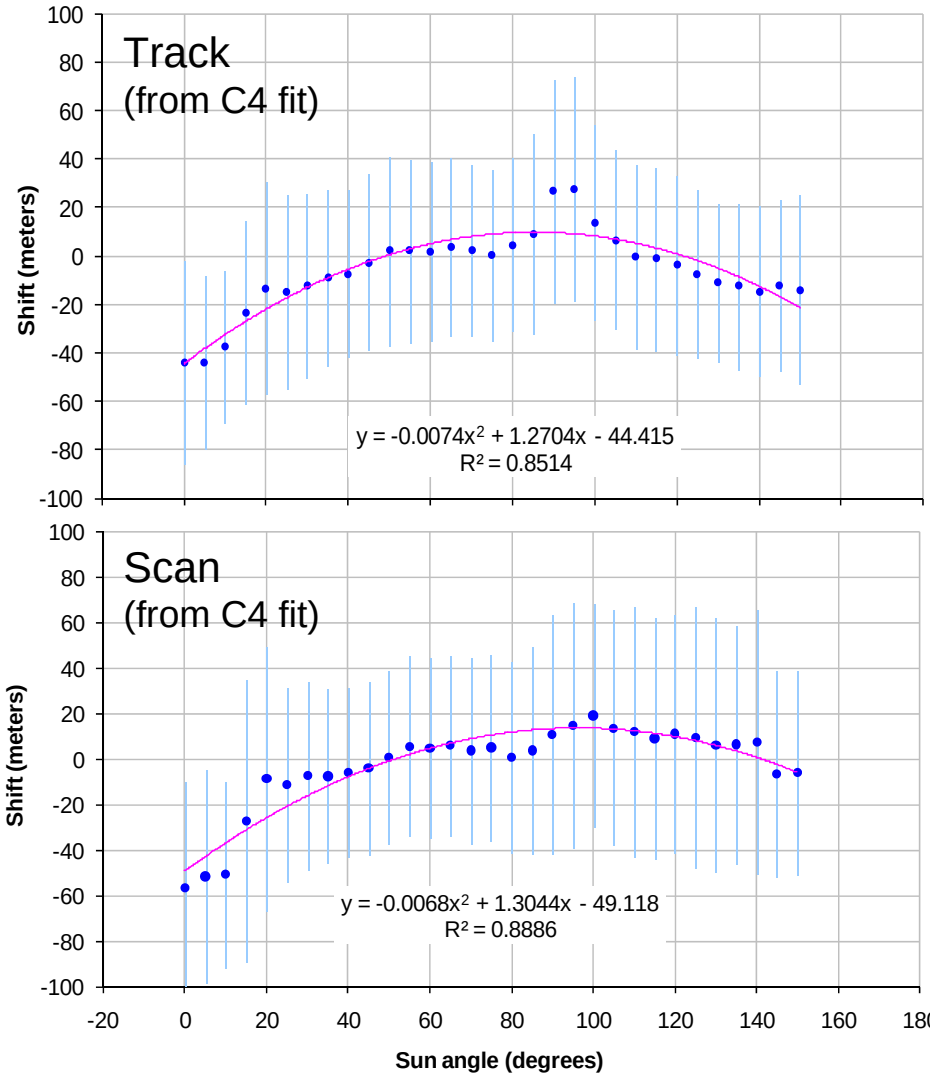
Expected Terra C6 residuals (prelim.)



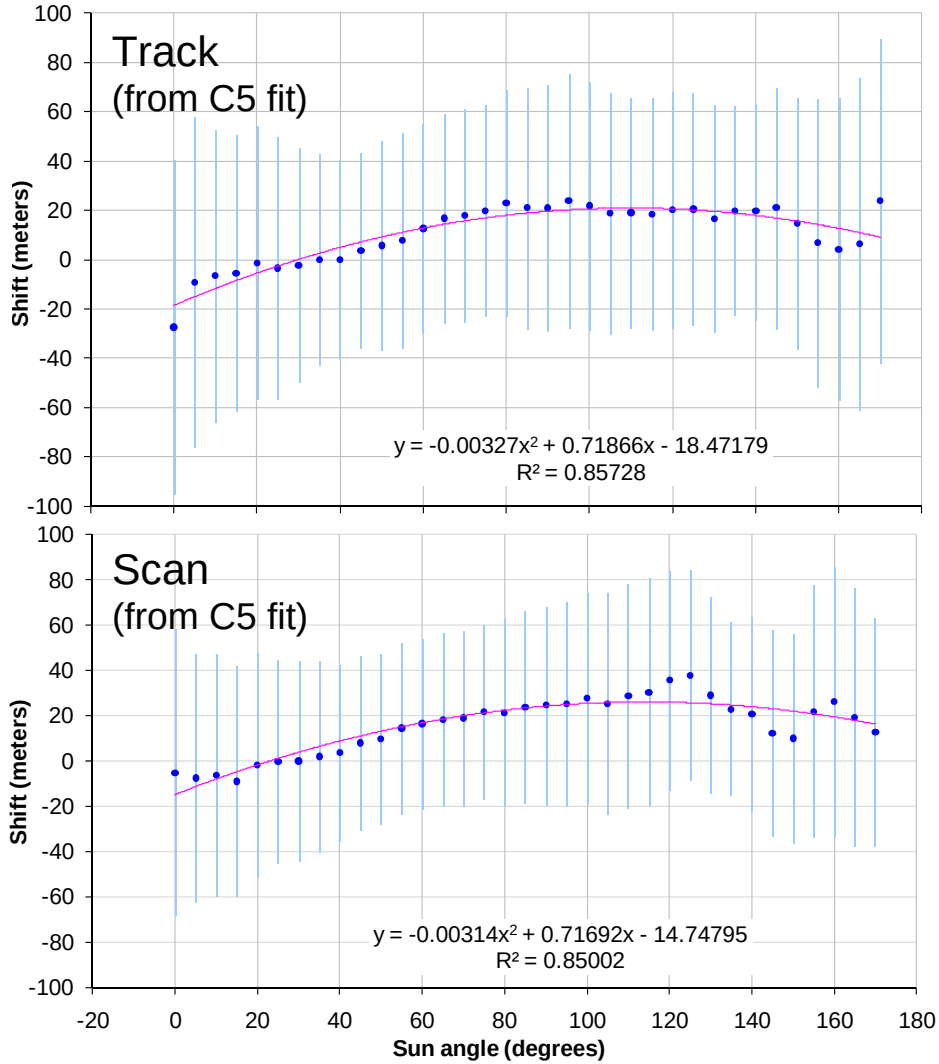
Track RMS: 42m (-1m vs C5) Scan RMS: 42m (-2m vs C5)

Terra Sun angle Correction

Used in C5



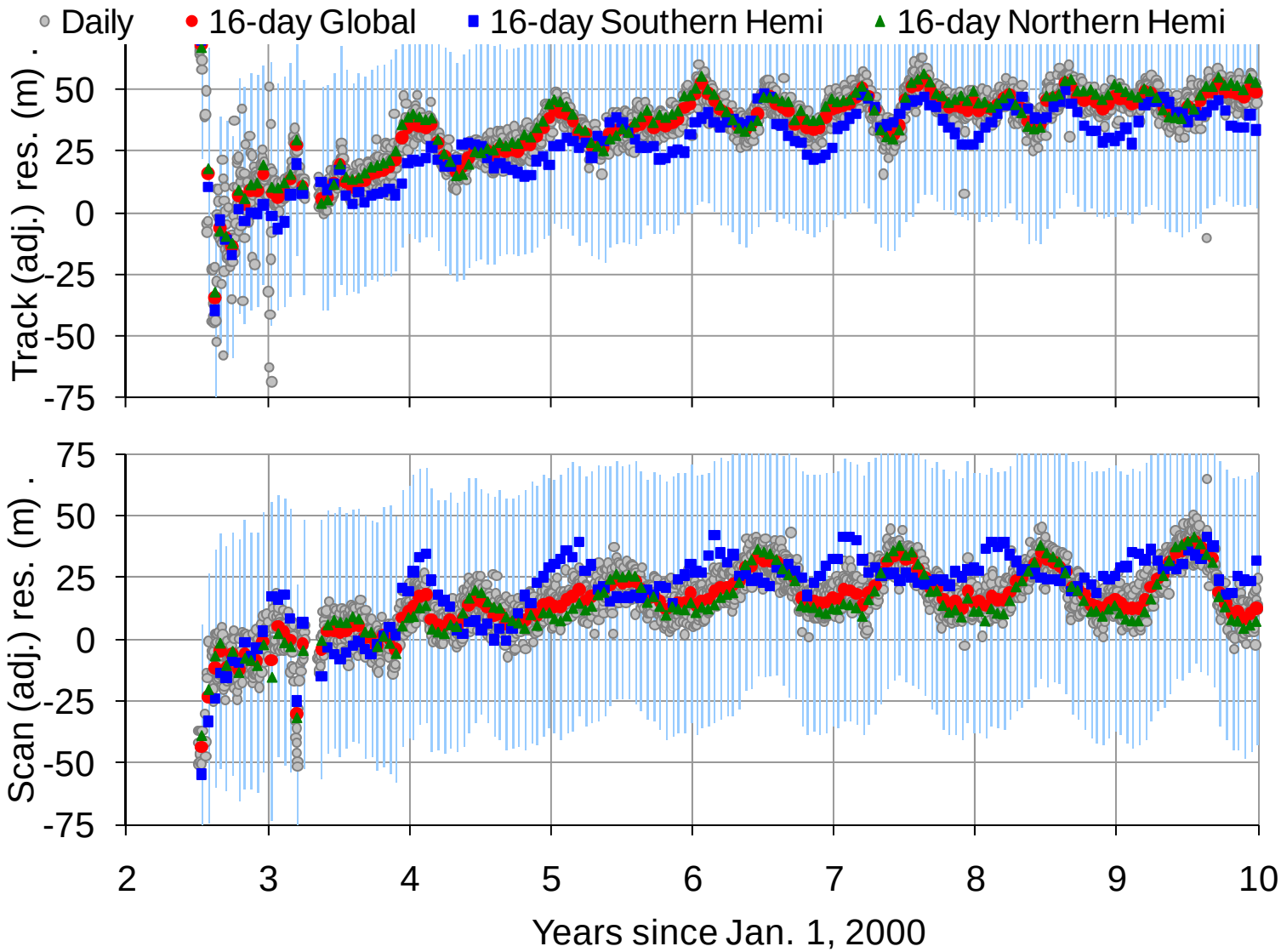
To be used in C6



Small overcorrect in C5 – will be corrected in C6

Aqua Long-term Trend Details

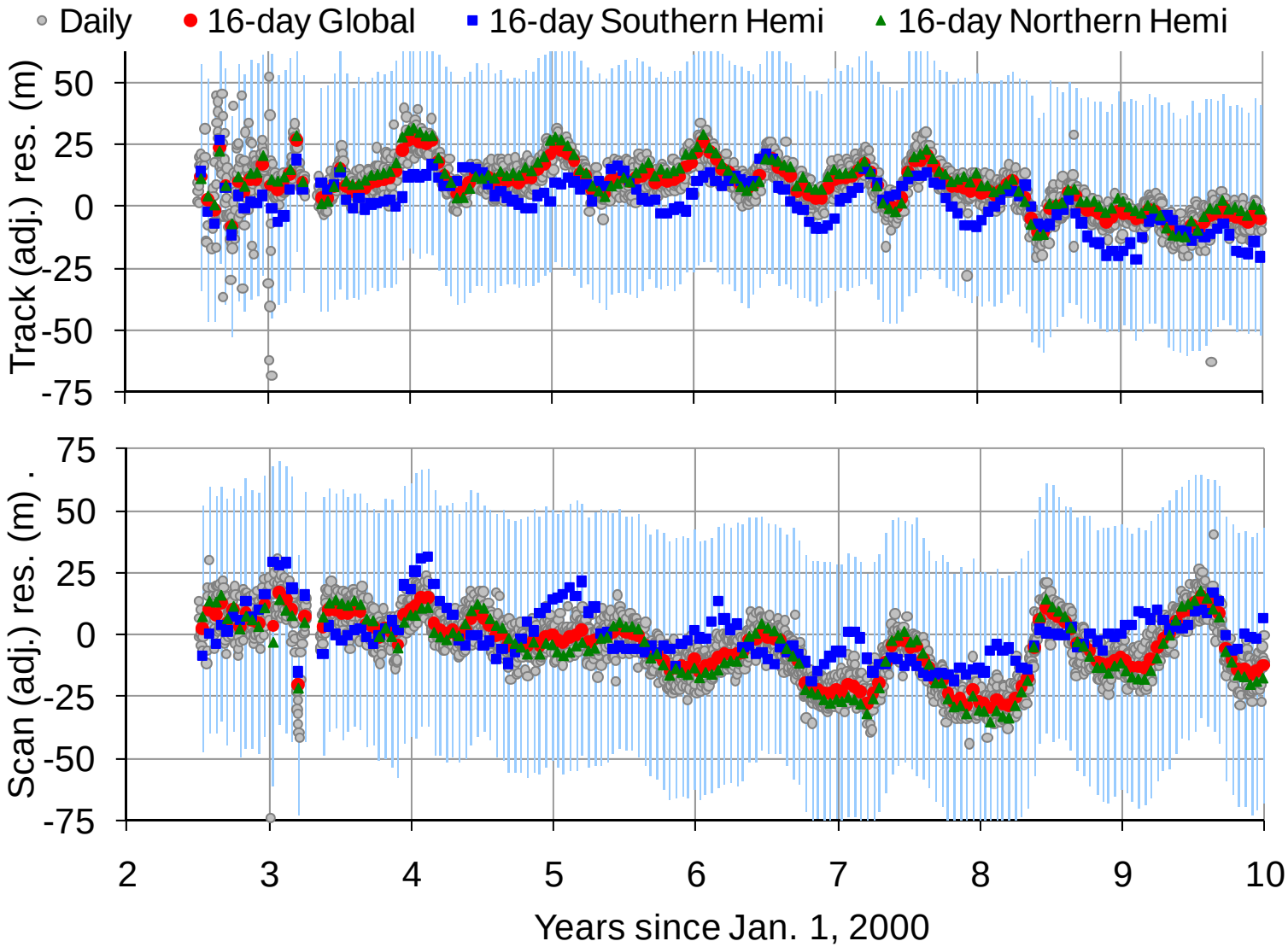
Aqua Long-term Trend (w/o Correction)



Track RMS: 59m (+12m vs C5) Scan RMS: 55m (+2m vs C5)

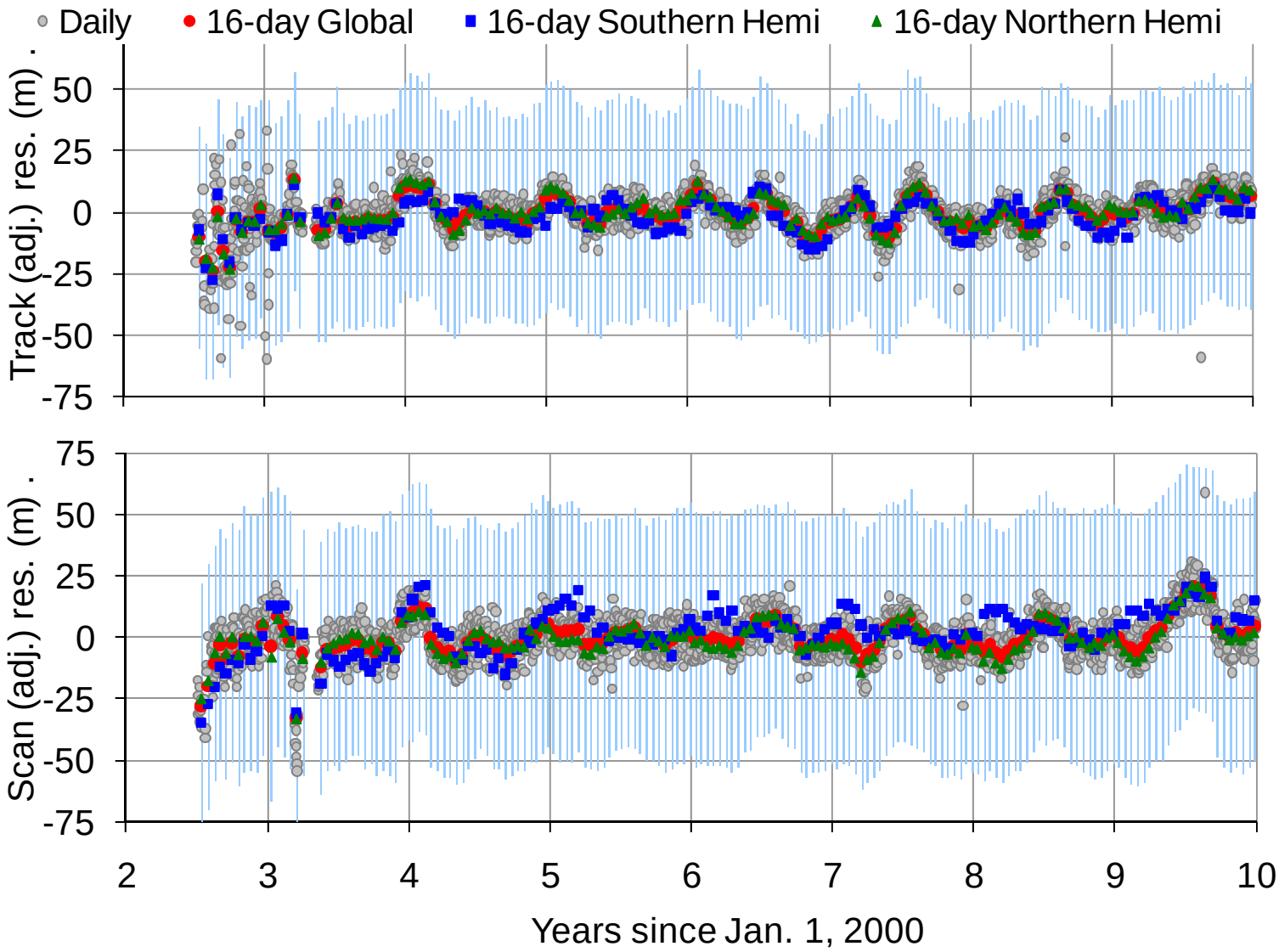
Actual Aqua C5 residuals

Note northern & southern hemispherical differences



Track RMS: 47m (C5) Scan RMS: 53m (C5)

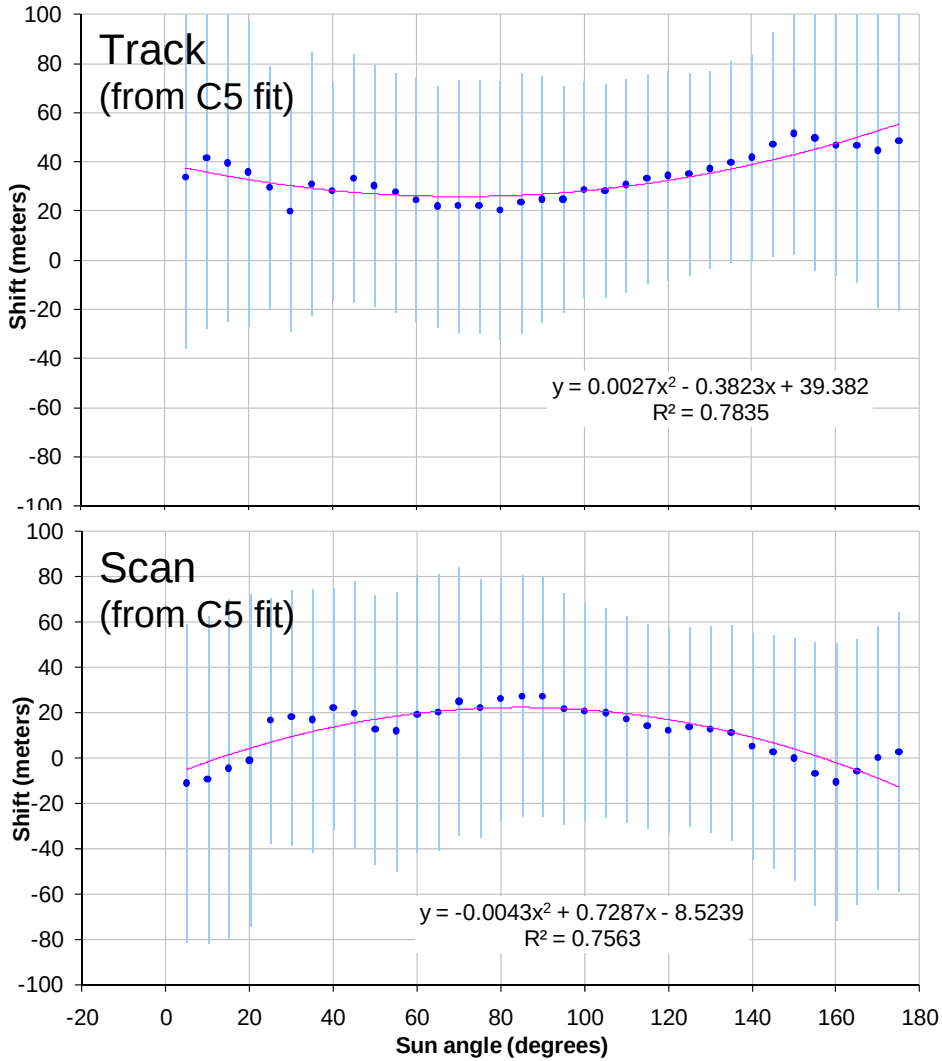
Expected Aqua C6 residuals (prelim.)



Track RMS: 45m (-2m vs C5) Scan RMS: 51m (-2m vs C5)

Aqua Sun angle Correction

Track and Scan sun-angle effects
- no correction in C5
- will be corrected in C6



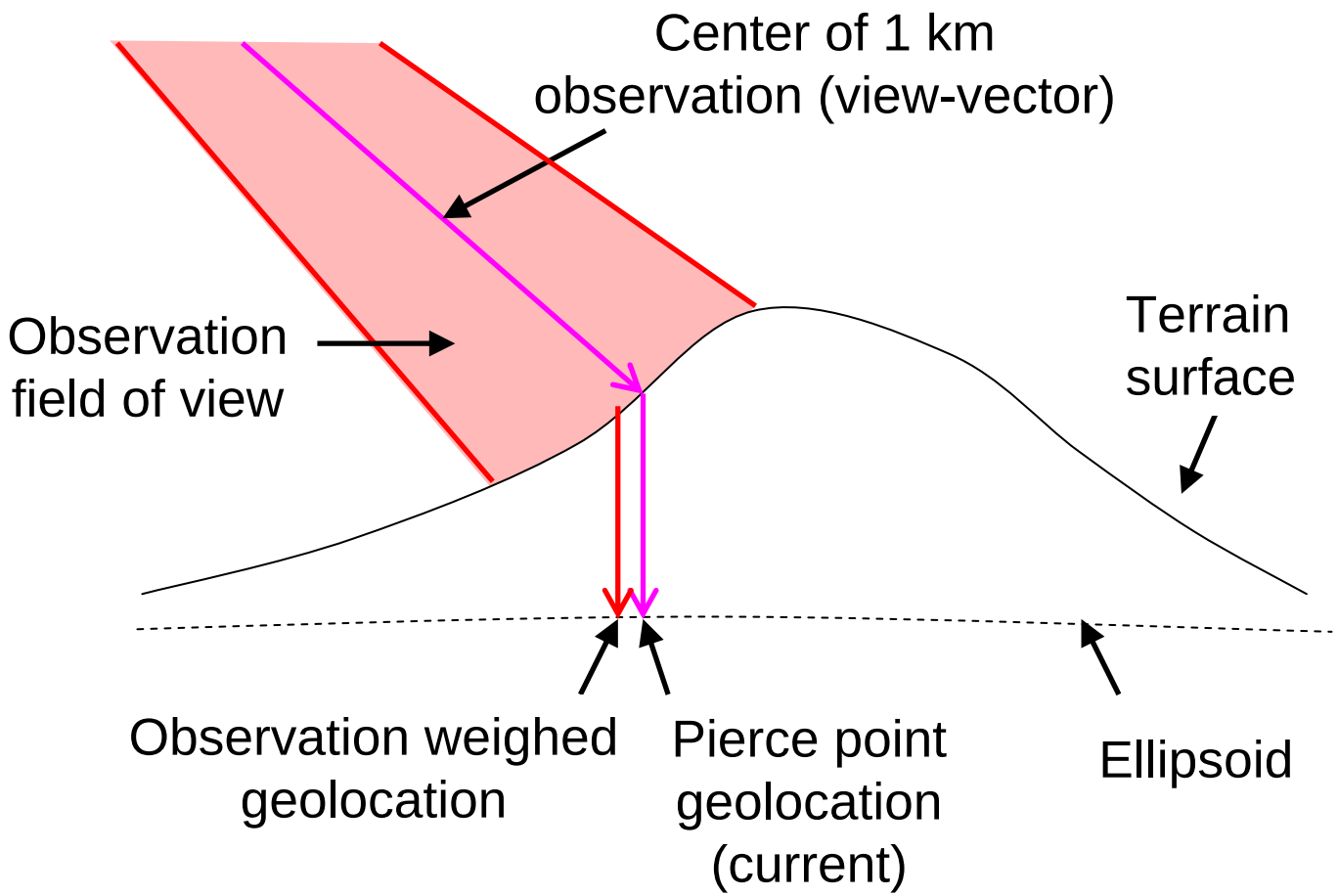
Maneuver Handling and C6 Changes

Maneuver Handling

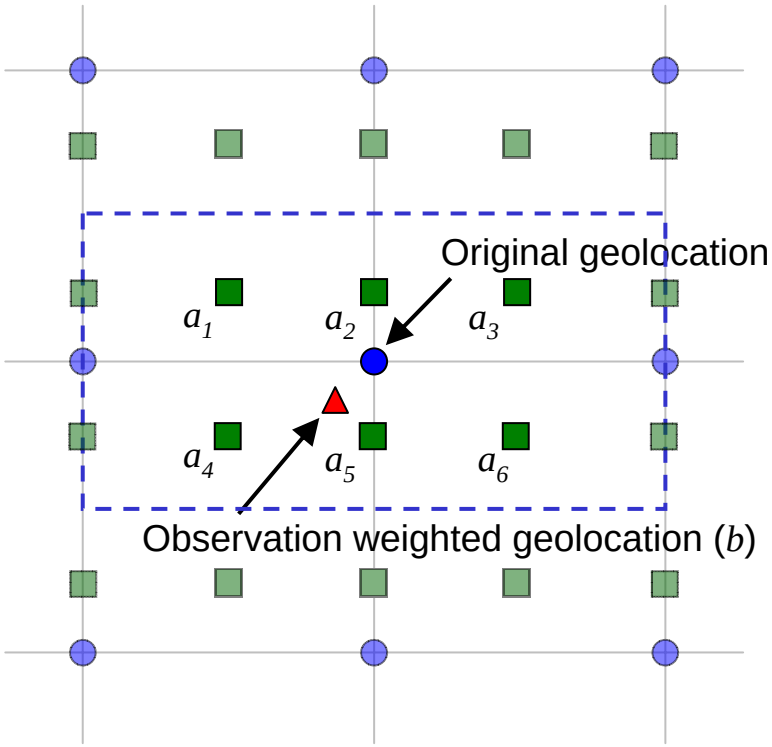
- Definitive maneuver lists (for both Aqua and Terra) have are being obtained regularly from FOT
- LDOPE routinely screens data near maneuvers to attempt to exclude this data from daily and higher level products
- Atmosphere hides L2+ products when geolocation errors exceed 1km
- Land will set QA low flags on L2+ products during times when the geolocation errors exceed specification (150m)
- For C6 the geolocation team will continue to work with the Terra and Aqua FOTs to find a better solution

Enhanced terrain correction (area based)

C6 change



First order method



– 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

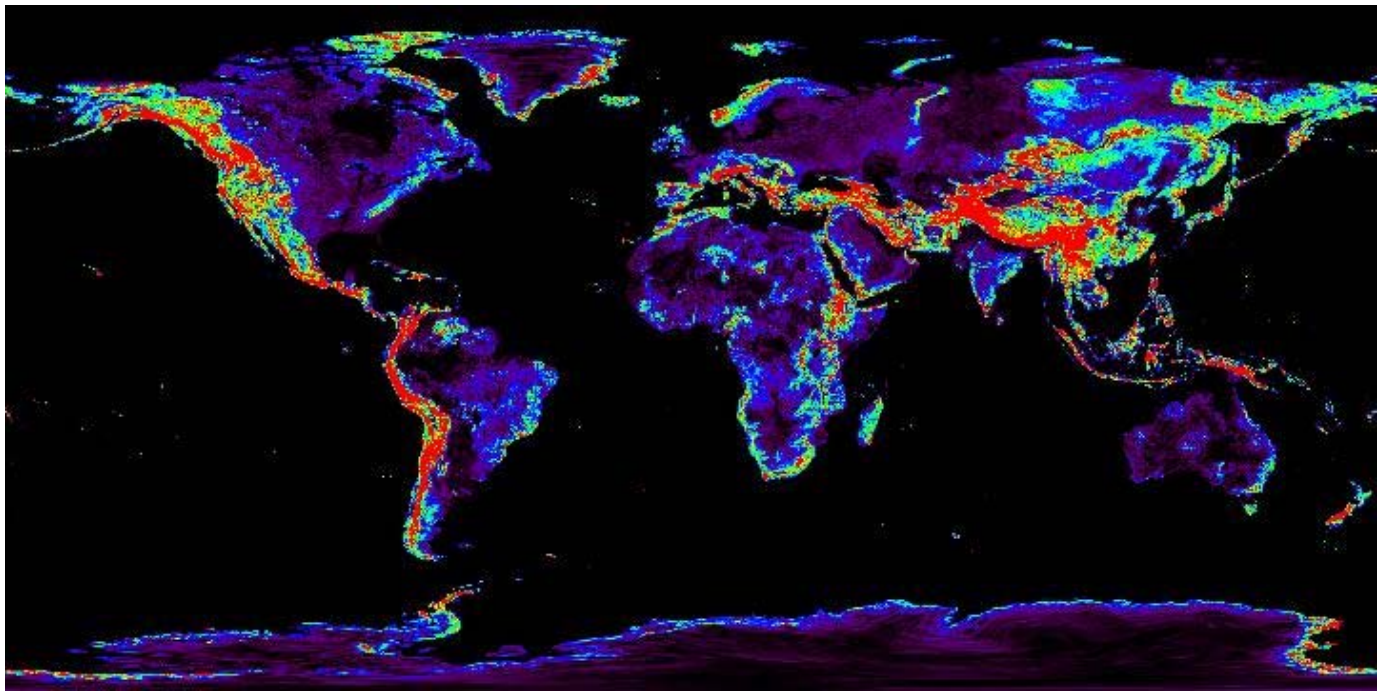
The first order approximation of the observation weighted point is:

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

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.

Global terrain elevation height variation

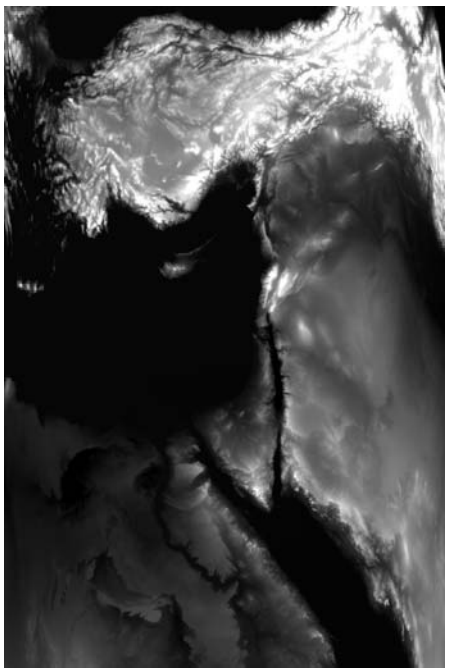
Local variation in global terrain height calculated by taking the difference between the minimum and maximum terrain height within each 5.6 km grid cell in an equal area grid



Over the land area, the local variation is 250m or more over 19% of the area, and 500m or more over 9% of the area

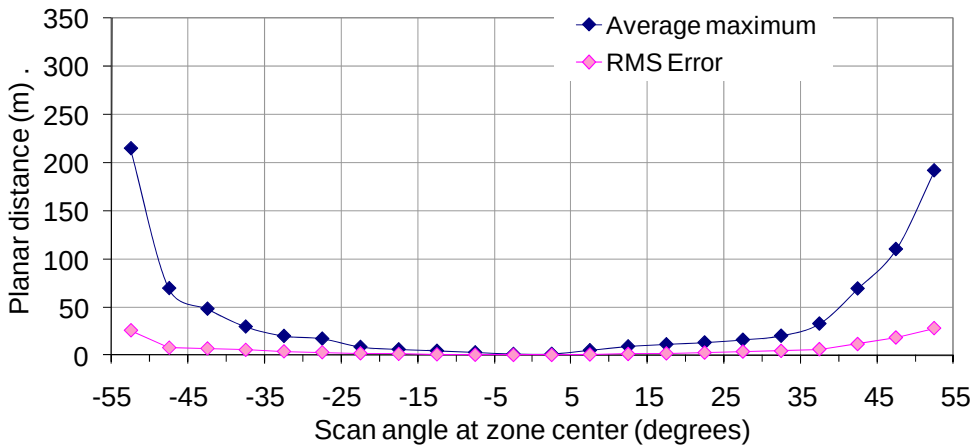
Example 1: Terra – Middle east

2001/199.0840



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

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

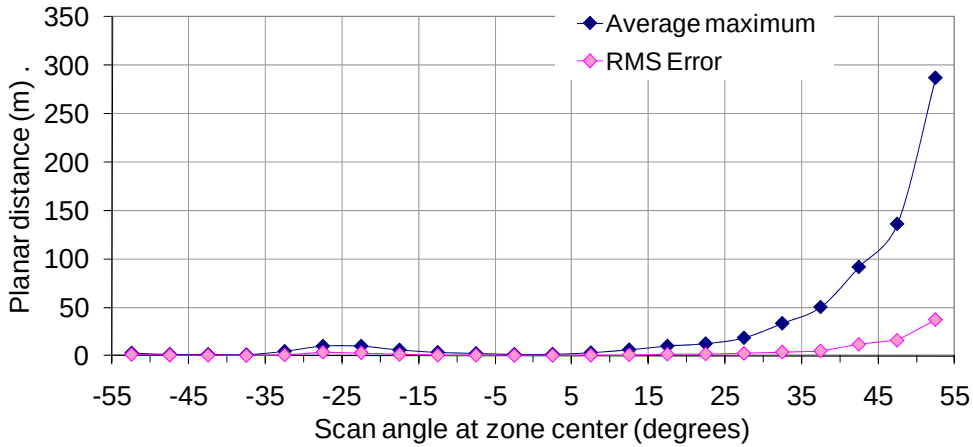


Example 2: Terra – US West Coast

2005/229.1855

Geolocation Elevation
(black: -75m, white: 2341m)

Geolocation difference
current minus obs. weighted
(black: 0m, white: 42m)

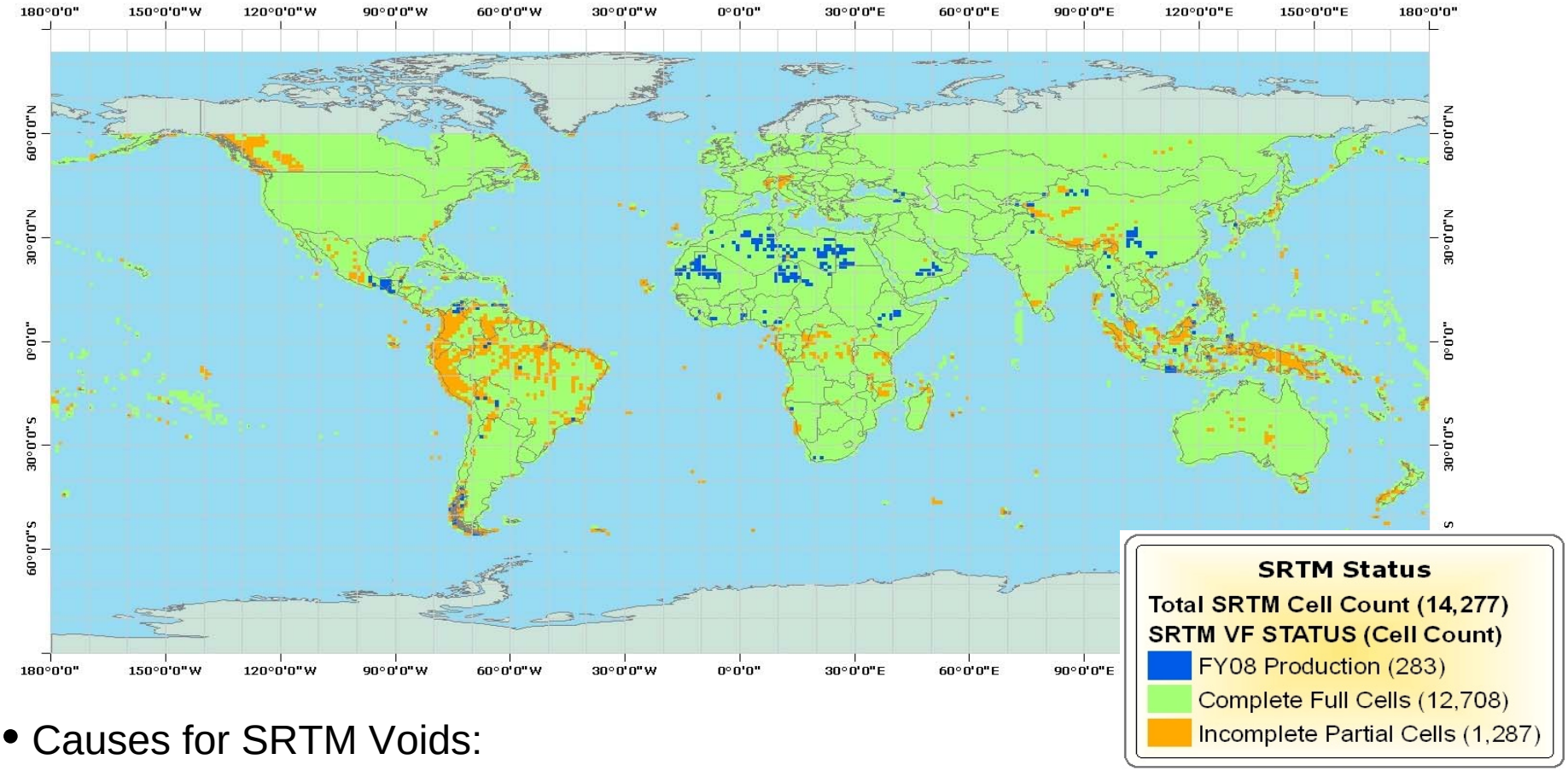


Global Digital Elevation Replacement Project

- USGS and NGA Project
- Primary Goal
  - To develop a fully global medium scale elevation model to replace and enhance GTOPO30. The new model will be generated at three separate resolutions (horizontal post spacings) of 30 arc-seconds (1 km), 15 arc-seconds (500 m), and 7.5 arc-seconds (250 m) from the best available higher resolution data sources.
- New Elevation Data Sources
  - Shuttle Radar Topography Mission (SRTM) DTED 2, 1 arc-second
  - US National Elevation Dataset (NED), 1 and 2 arc-seconds
  - Canadian Digital Elevation Data (CDED), 0.75 and 3 arc-seconds
  - SPOT5 Reference3D, 15 arc-second
  - ICESat Geoscience Laser Altimeter System (GLAS), 15 and 30 arc-seconds
  - Radarsat Antarctica Mapping Project (RAMP) Ver. 2, 6 arc-second
  - Australian GEODATA 9 arc-second DEM
  - Digital Terrain Elevation Data (DTED 1), 3 arc-second

Source: Danielson et al. (USGS) and NGA

SRTM Voids



- 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 the Sand Surface Texture

Source: Danielson et al. (USGS) and NGA

Elevation Model Comparison

DEM	New Global Model	GTOPO30	SRTM	ASTER GDEM
Resolution	30 arc-sec 15 arc-sec 7.5 arc-sec	30 arc-sec	3 arc-sec 1 arc-sec	1 arc-sec
Coverage	Global	Global	60° N to 56° S	83° N to 83° S

- New Global Elevation Model:
  - Global, Continental and Regional Applications (not requiring 1 or 3 arc-sec data)
  - SRTM Voids Filled
  - Will Use ASTER GDEM as Source Data for 60° N to 83° N (if available during project timeline)
  - Will Use ASTER GDEM as Source Data for Void Filling (if available during project timeline)

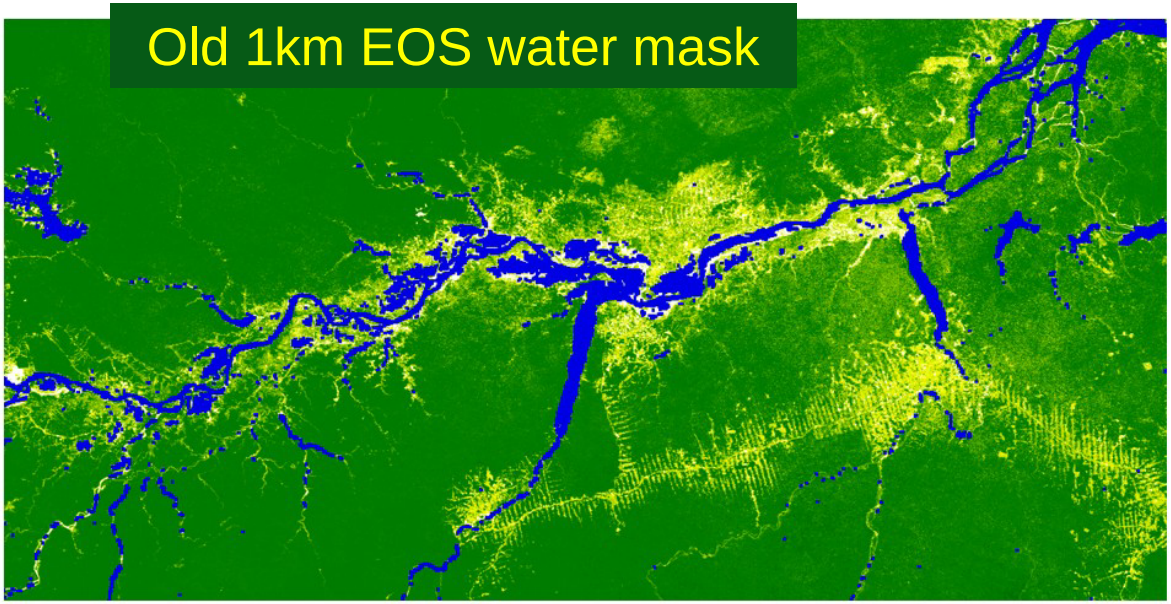
Source: Danielson et al. (USGS) and NGA

New DEM Issues

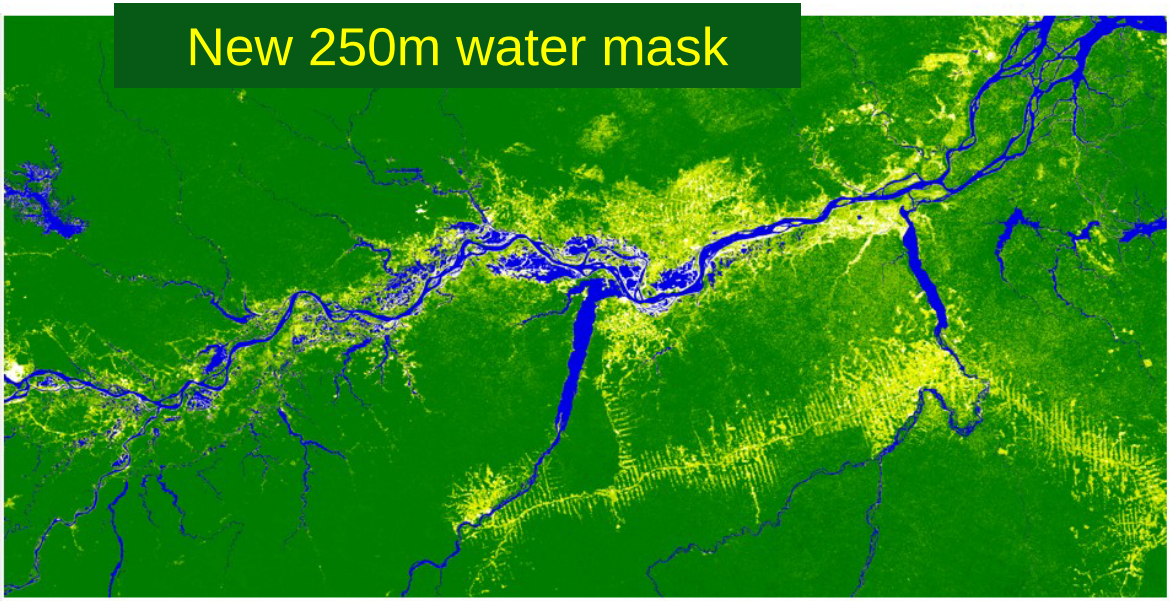
- Current DEM
  - SRTM based gap filled
  - We are uncertain about the heritage of the approach to reducing resolution and gap filling
  - Only available at 30 arc-sec (~1km) DEM
  - New DEM
  - Also available at 15 arc-sec (~500m)
  - Better data is now available for gap filling (ASTER GDEM, etc.)
  - Using best available approach to reducing resolution and gap filling
- However, timeline for sample and full data set has slipped
  - Originally, sample assessment data over Eurasia was to be available Jan. 2010. This has slipped 2-3 months.
  - Full data set now expected in June 2010
  - Meets the Land/Atmosphere C6 schedule, but pushes L1 C6 start date to July 2010

New Land/Water Mask for C6

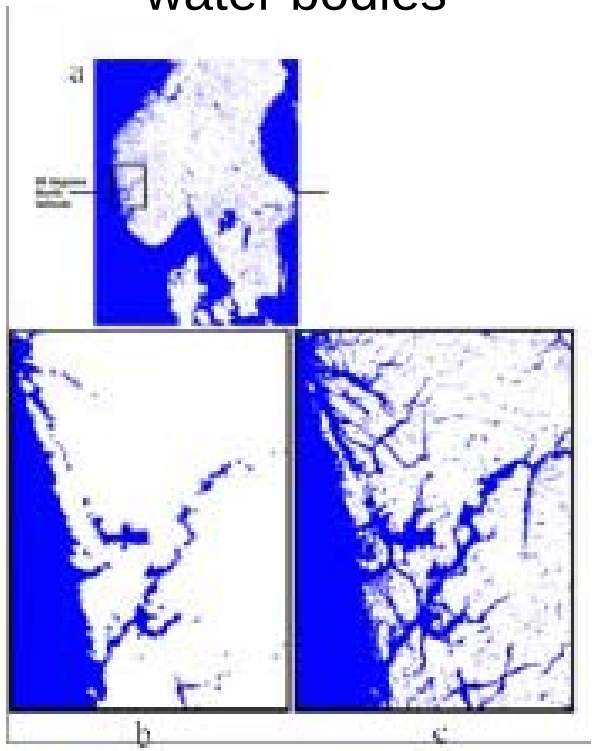
Old 1km EOS water mask



New 250m water mask



Improved inland water bodies



Planned C6 Changes (1 of 2)

Algorithm (Science) Changes

1. Update error analysis: using C5 residuals update long-term trend, biases and sun-angle corrections
2. Incorporate new ancillary data
   a. Improved 500m Shuttle Radar Terrain Mission (SRTM) Digital Elevation Model data
   b. Improved UMD developed Land/water mask
3. Compute 500m geolocation (using 500m SRTM) 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 [still under consideration]
6. Develop and implement an algorithm to remove the AMSR-E jitter from Further improve maneuver handling the along-scan mirror motion for MODIS/Aqua [no longer planned]
7. Improve geolocation quality near maneuvers

Planned C6 Changes (2 of 2)

Other Changes

8. Write the solar elevation correction (roll, pitch and yaw) to geolocation product, for transfer to the Control Point Residual files
9. Add a scan metadata reporting the quality and type of the ephemeris/attitude data used in the calculations
10. For some users (DB and maybe Ocean): Add file level metadata indicating whether or not terrain correction was performed. There are no current plans to turn off terrain correction in MODAPS.
11. 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?