



# MODIS Geolocation Status

MODIS/VIIRS ST Meeting  
Calibration Breakout Session

May 17, 2011

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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 ~1.5 hr after maneuvers (about 12 per year)
  - accuracy in following orbit suspect

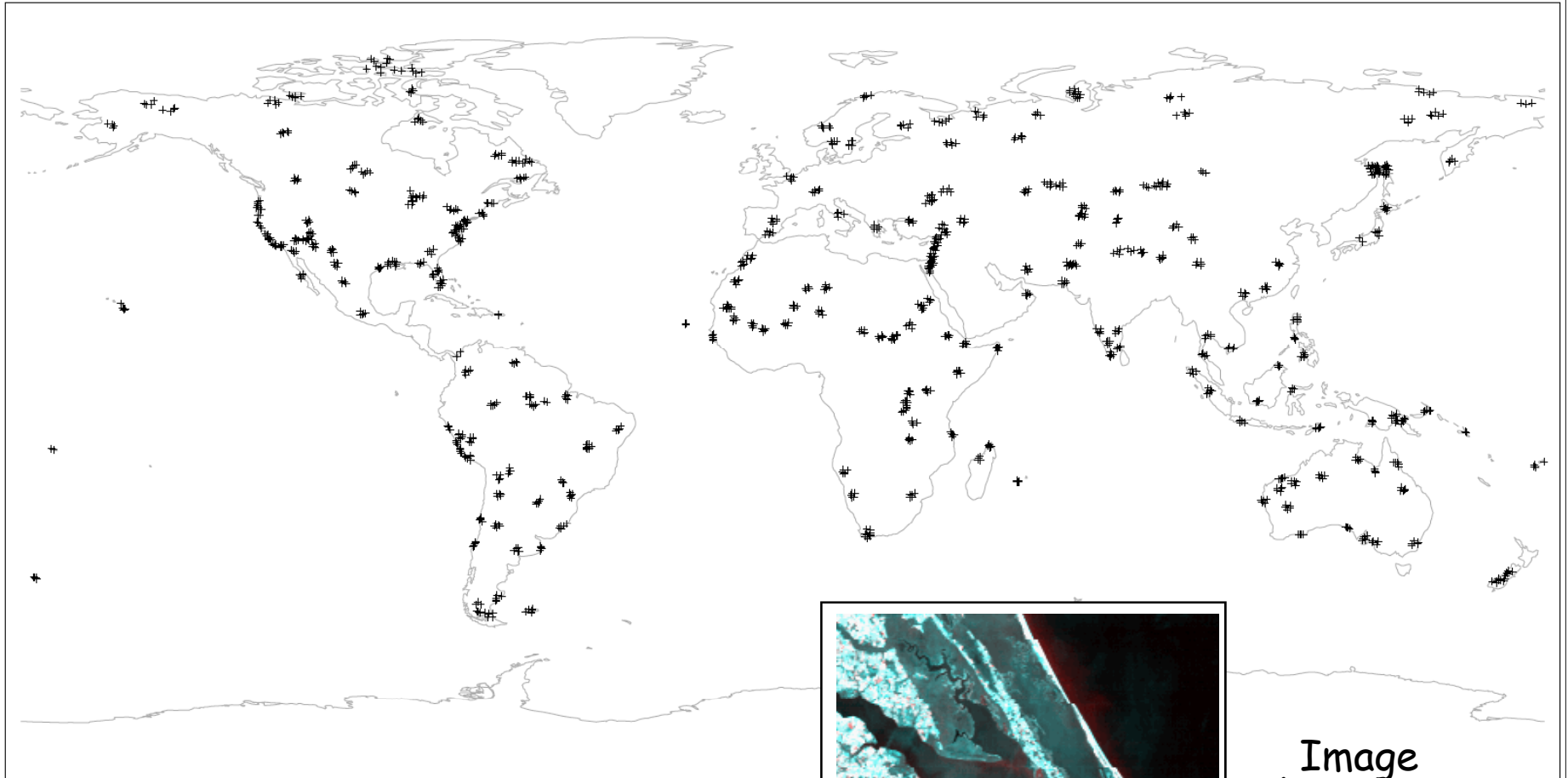
## Aqua

- 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

	<b>Terra</b>	<b>Aqua</b>
Along-track RMS error (m)	43	47
Along-scan RMS error (m)	44	53
Years of Data	11.1	8.8
Ground Control Point Match-ups/day	267	230



# Ground Control Points (GCPs)



1214 GCPs used in C5

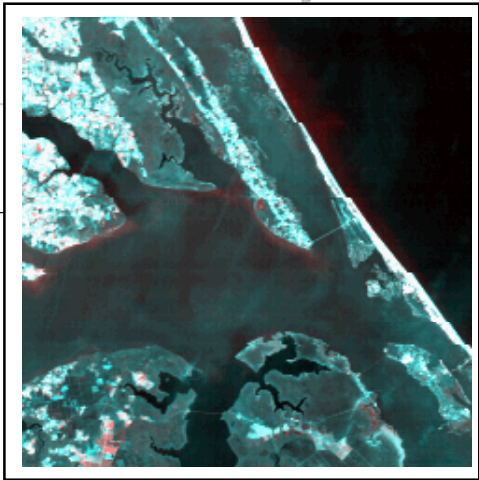


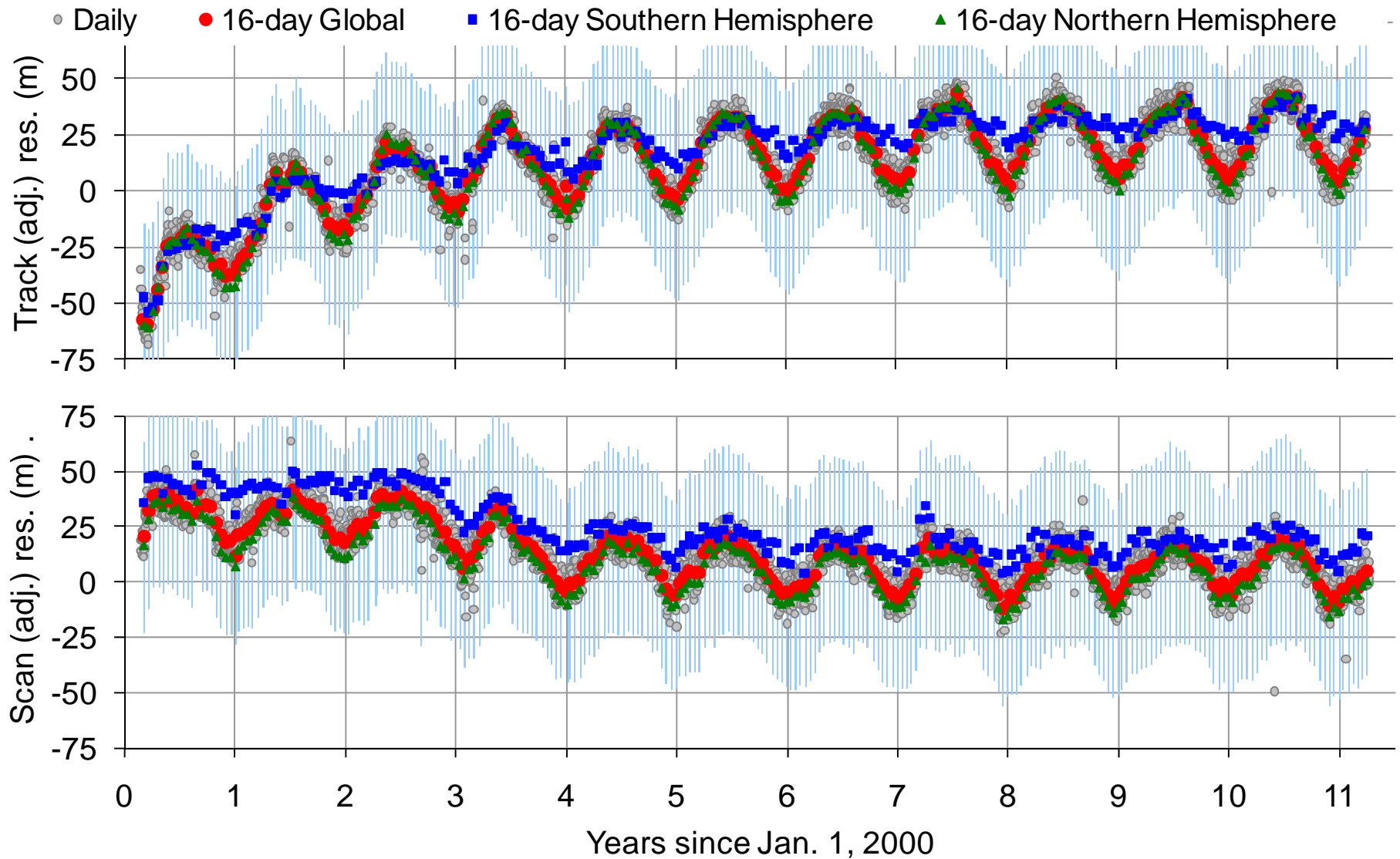
Image chips from Landsat TM/ETM scenes



# Terra Long-term Trend Details

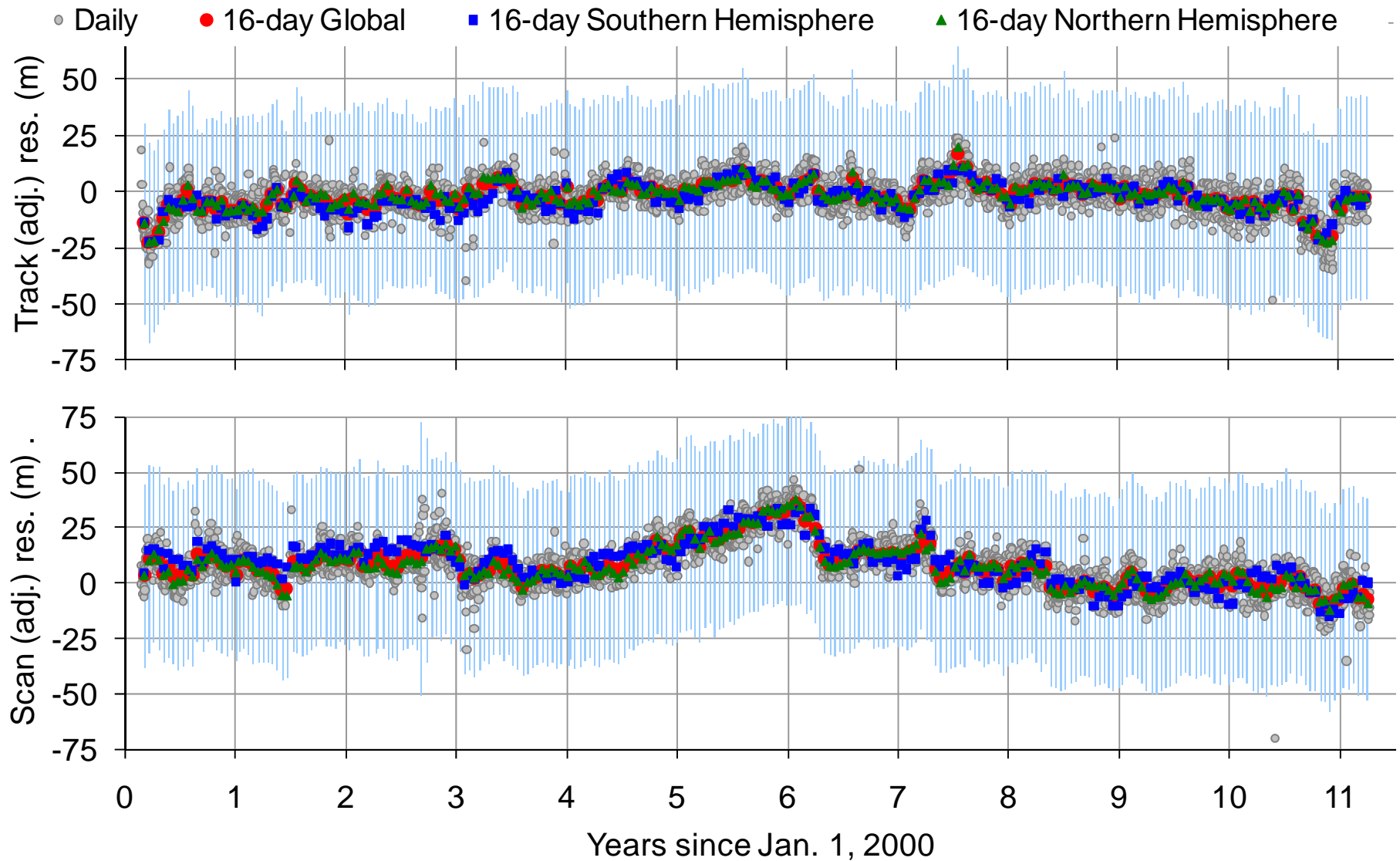


# Terra Long-term Trend (w/o Correction)



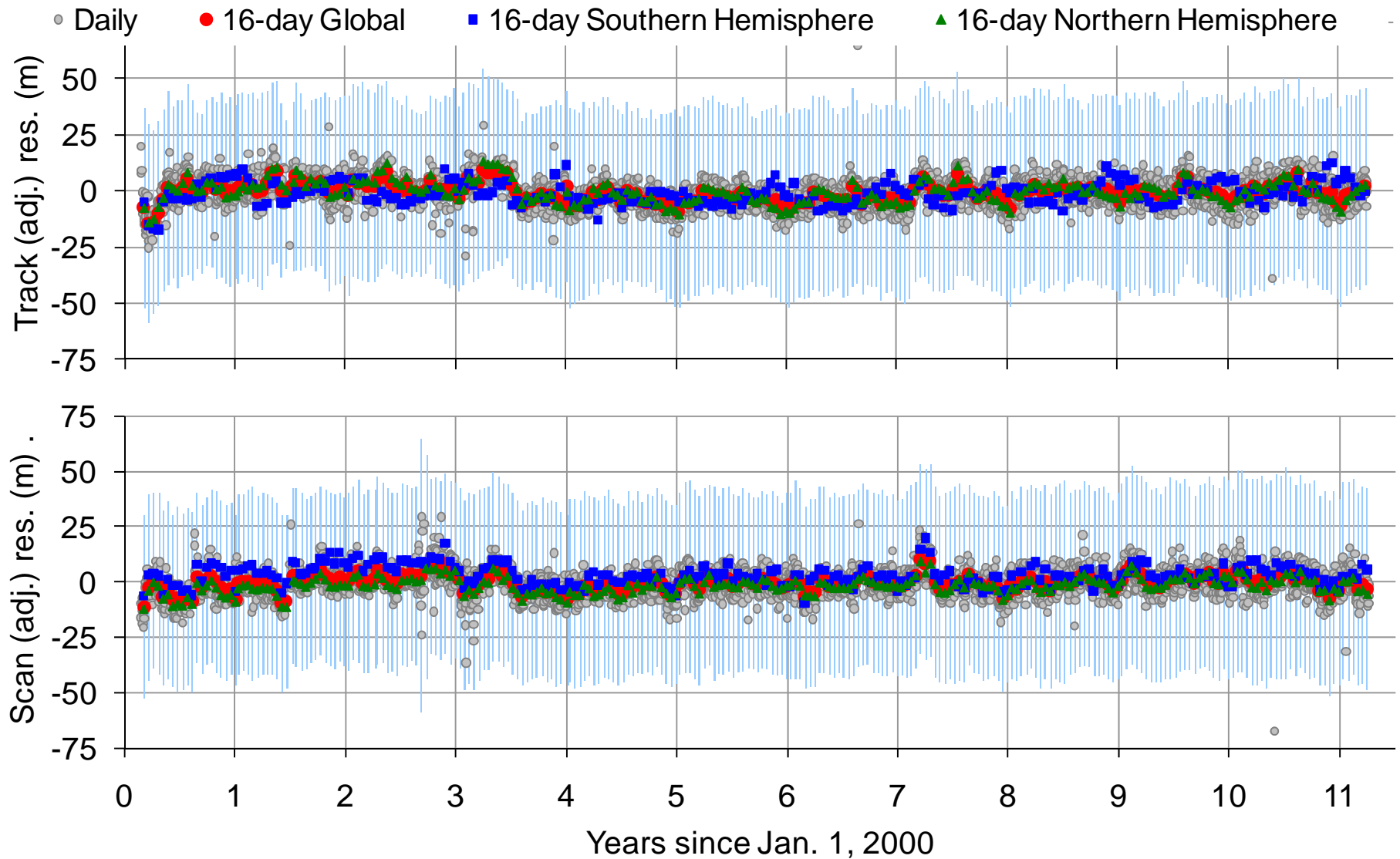


# Actual Terra C5 residuals





# Expected Terra C6 residuals

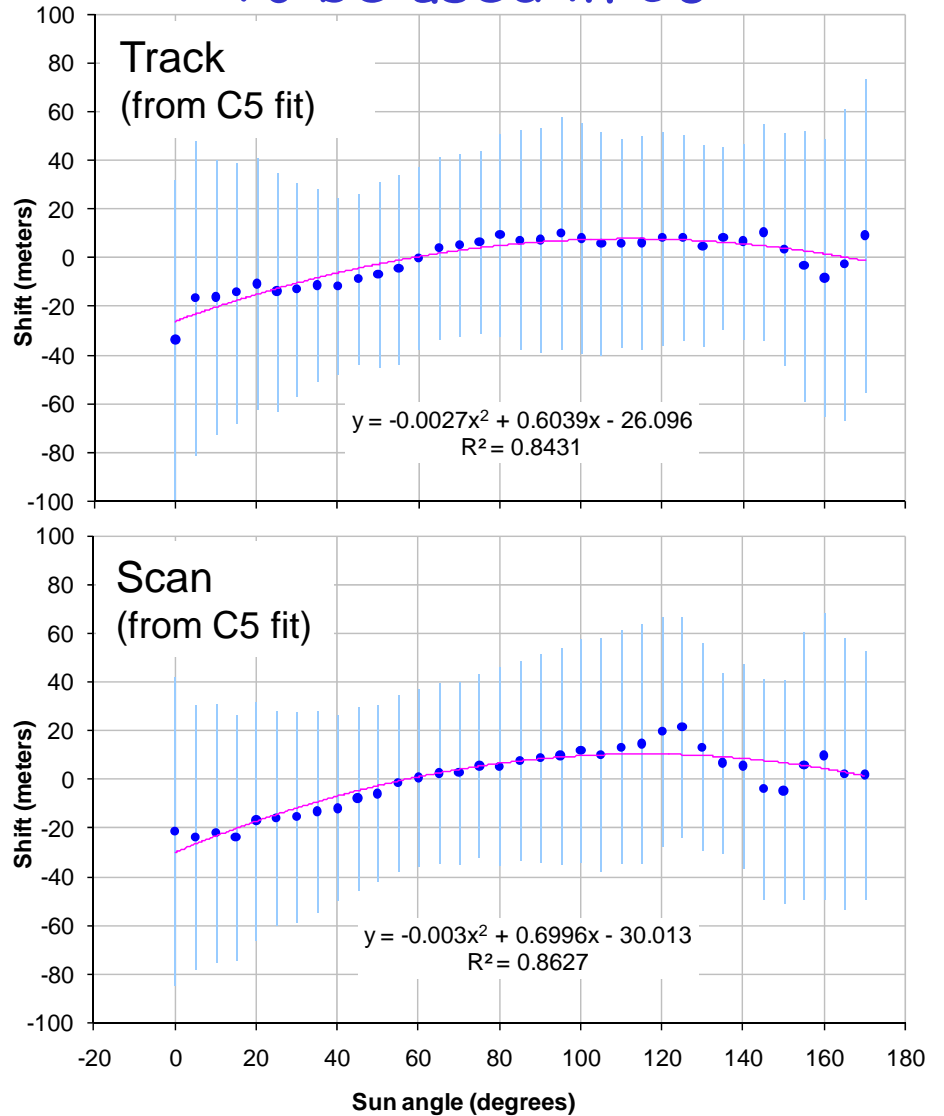
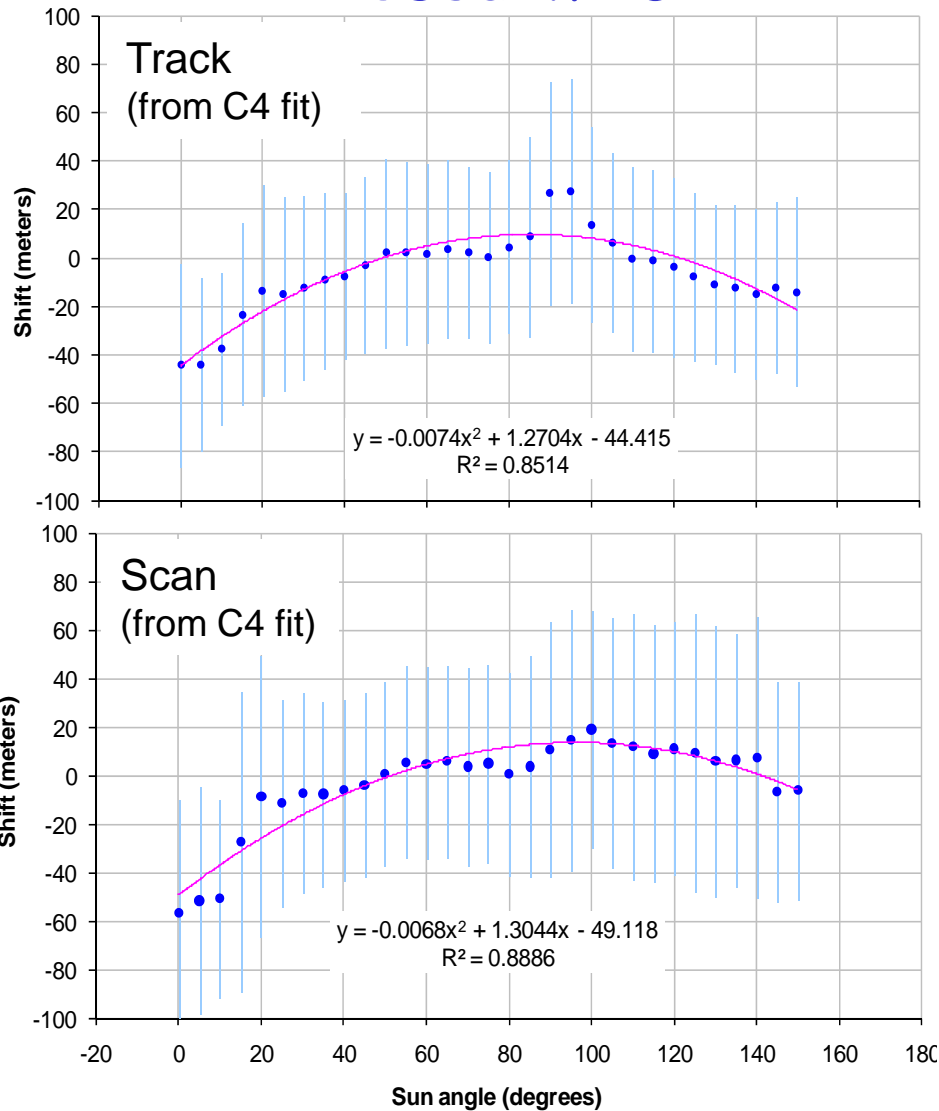




# Terra Sun angle Correction

Used in C5

To be used in C6



Small overcorrect in C5 - will be corrected in C6

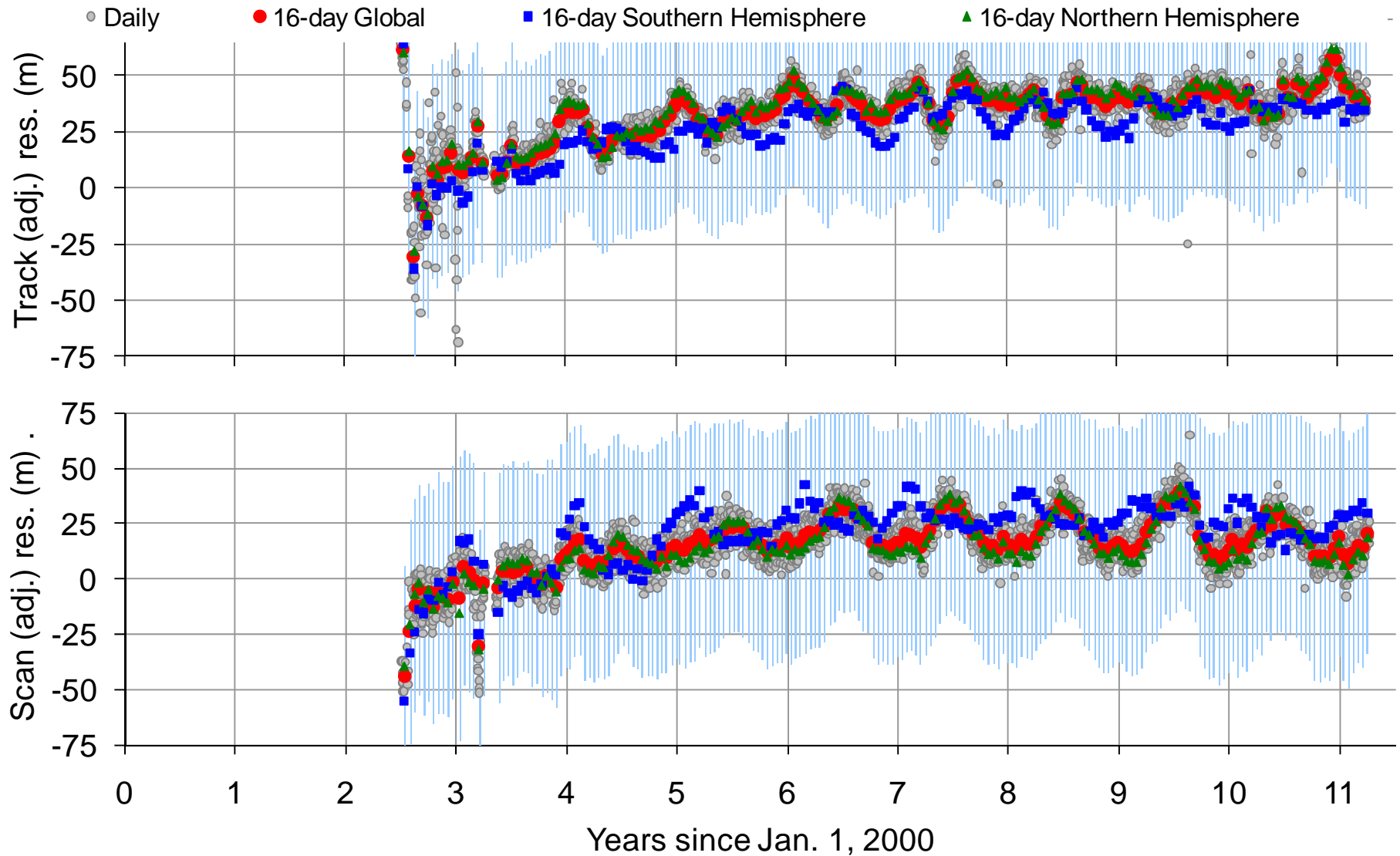




# Aqua Long-term Trend Details

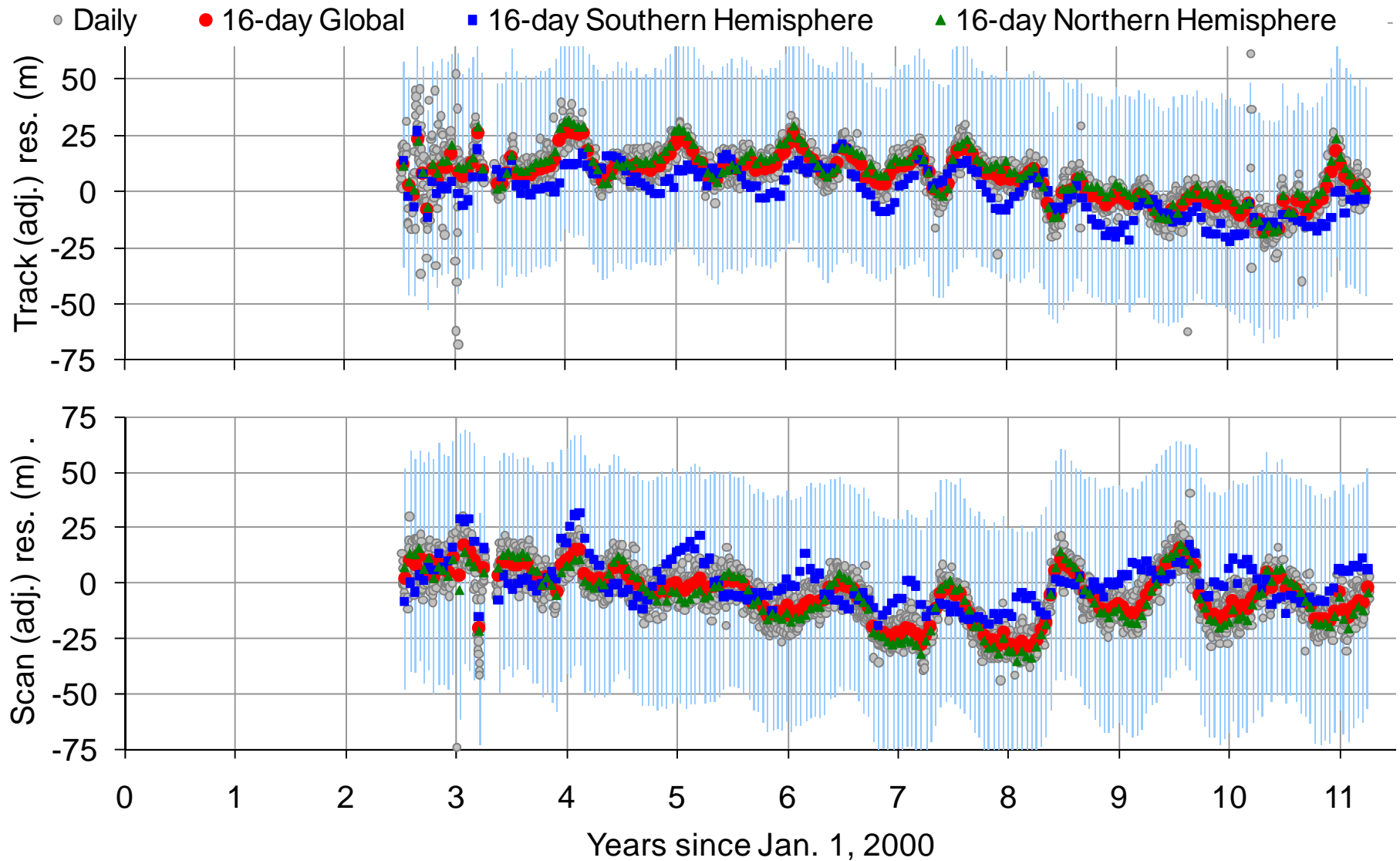


# Aqua Long-term Trend (w/o Correction)



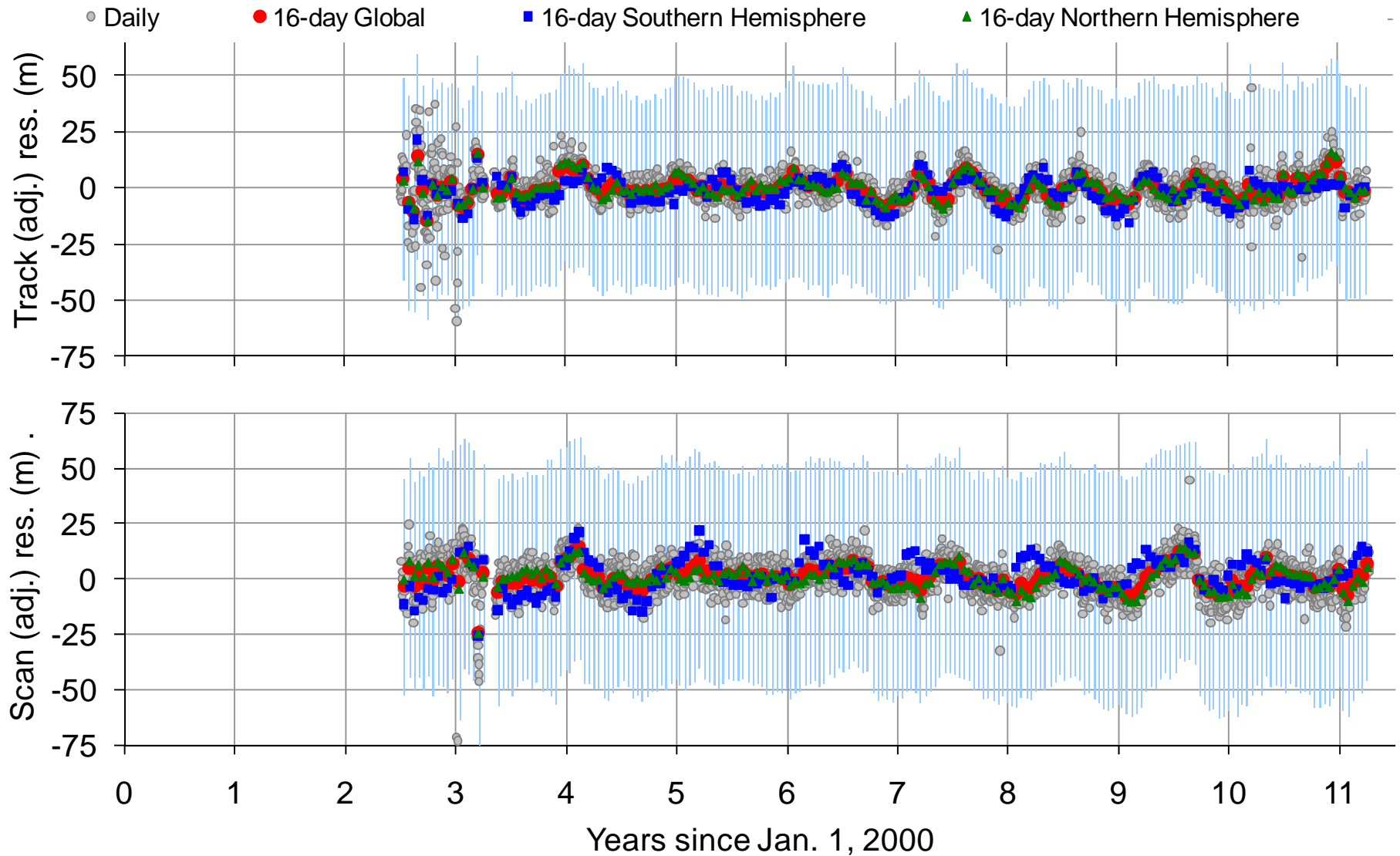


# Actual Aqua C5 residuals





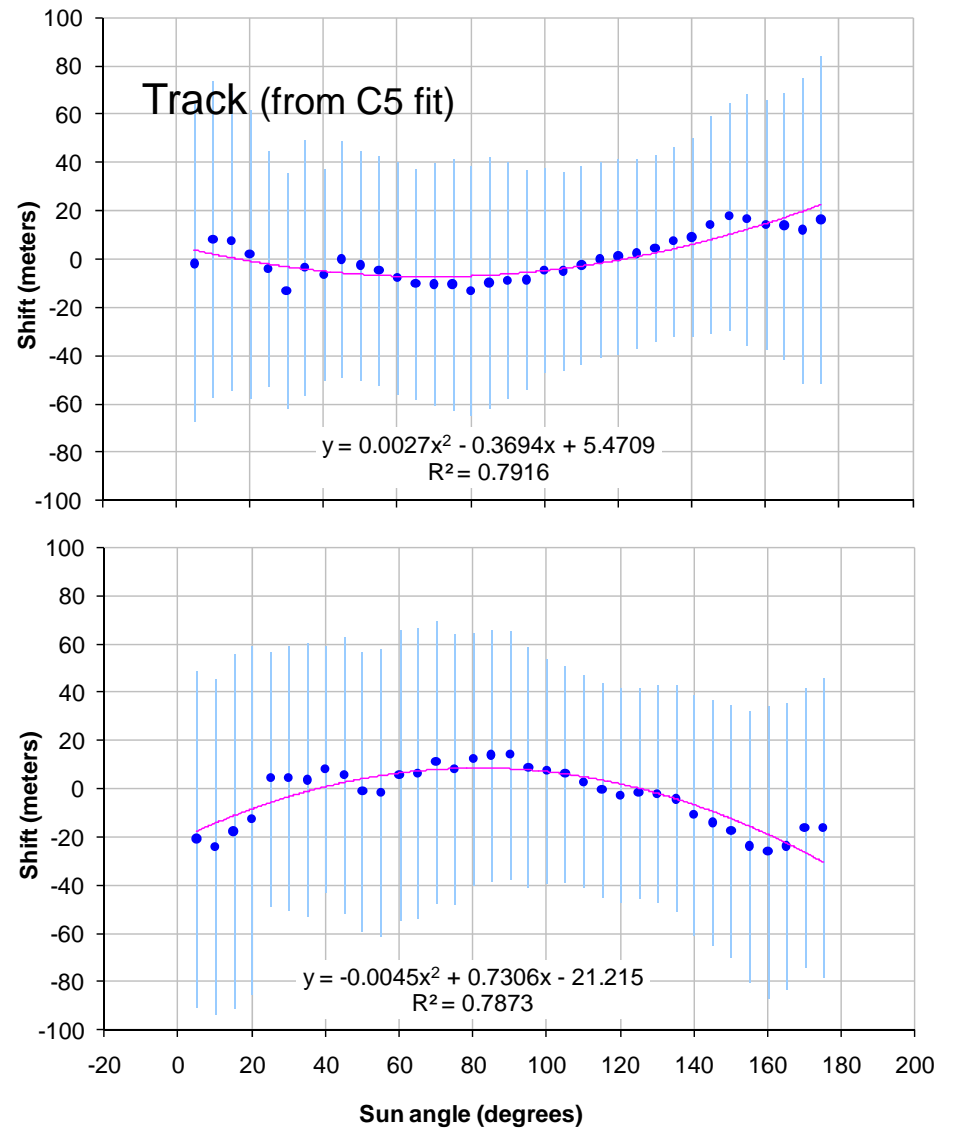
# Expected Aqua C6 residuals





# Aqua Sun angle Correction

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





# Maneuver Handling and C6 Changes



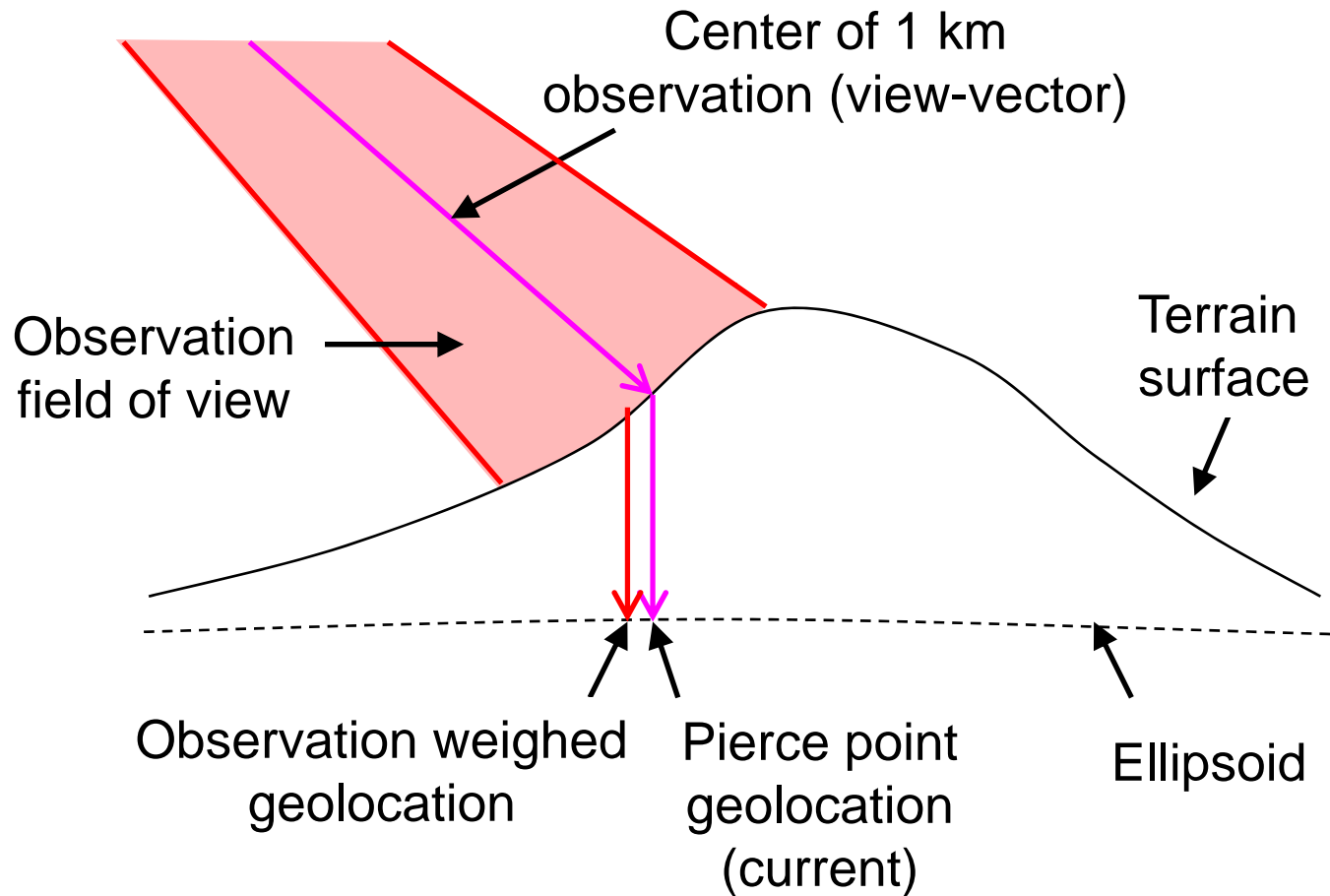
# Maneuver Handling

- 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)

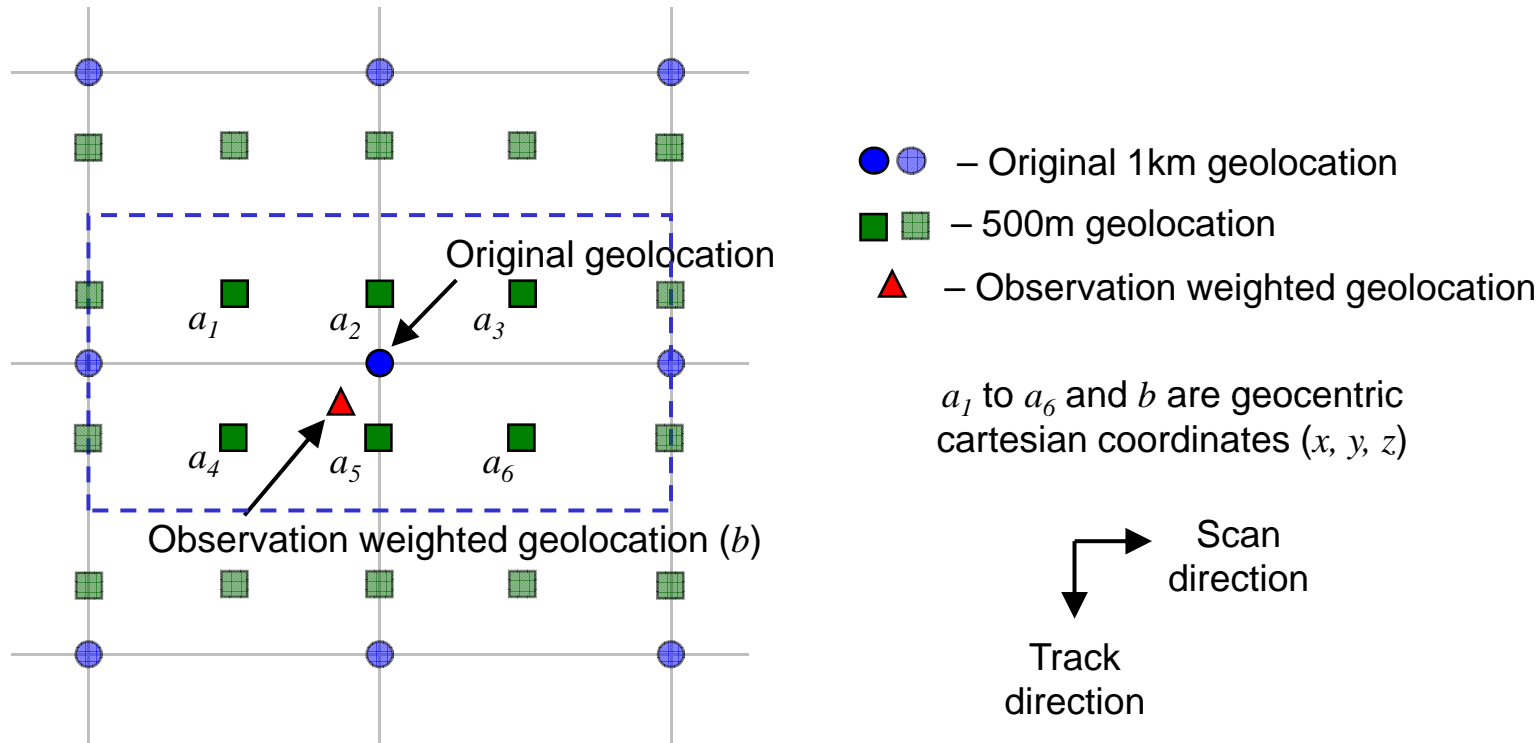
C6 change







# First order method



The first order approximation of the observation weighted point is:

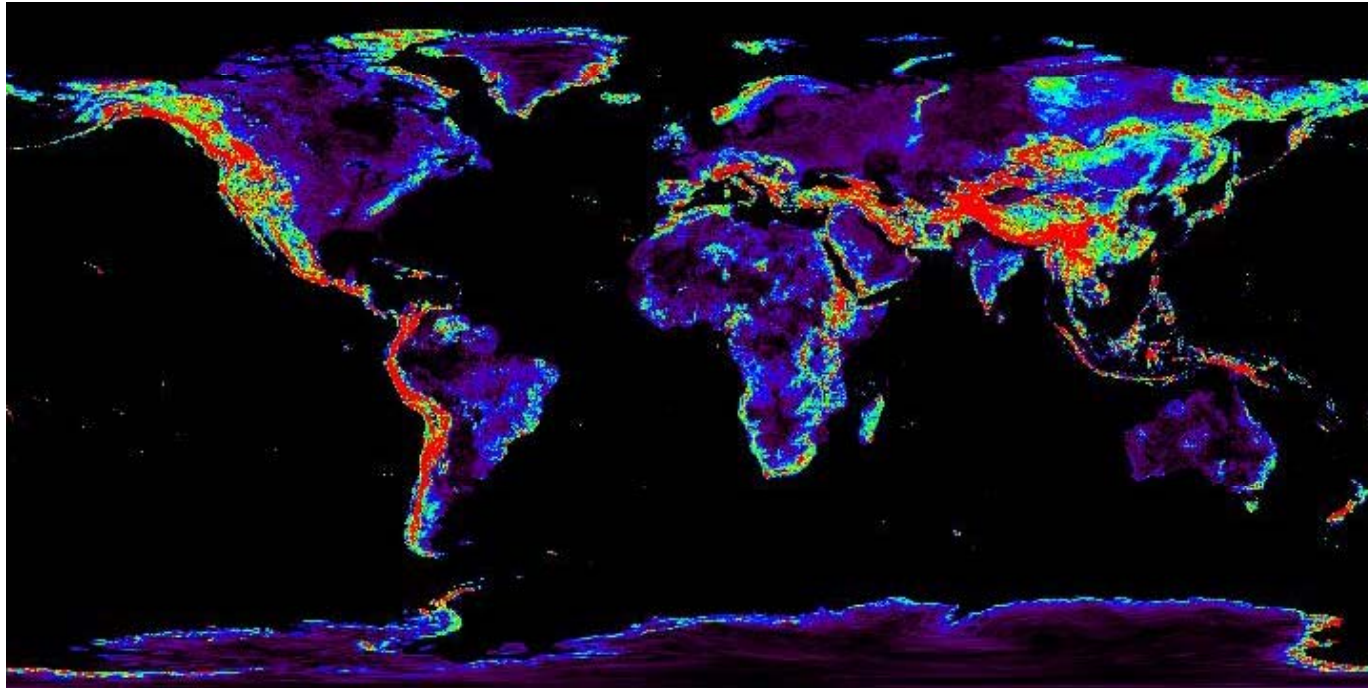
$$b = \frac{(a_1 + a_3 + a_4 + a_6) w_1 + (a_2 + a_5) w_2}{4 w_1 + 2 w_2}$$

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

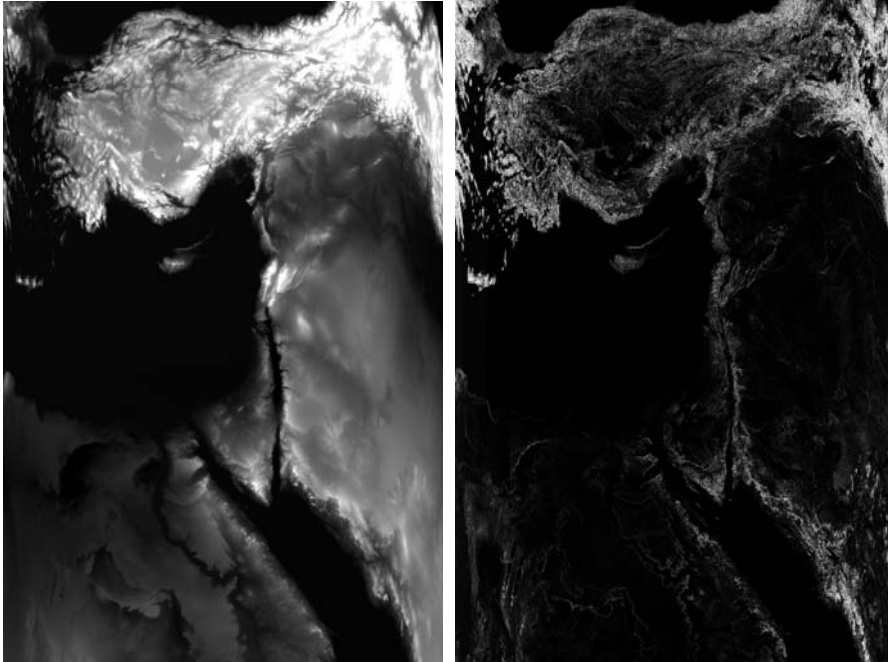


Over the land area, the local variation is 250m or more over 19% of the area, and 500m or more over 9% of the area



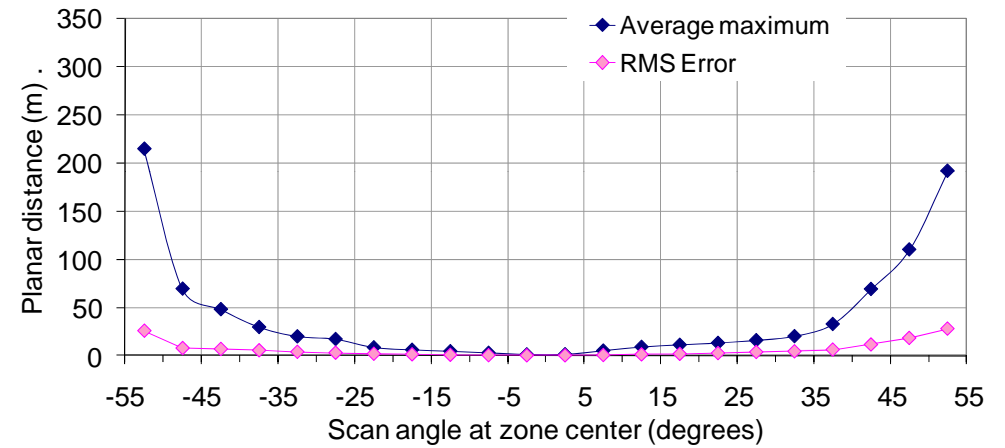
# Example: Terra - Middle east

2001/199.0840



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

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



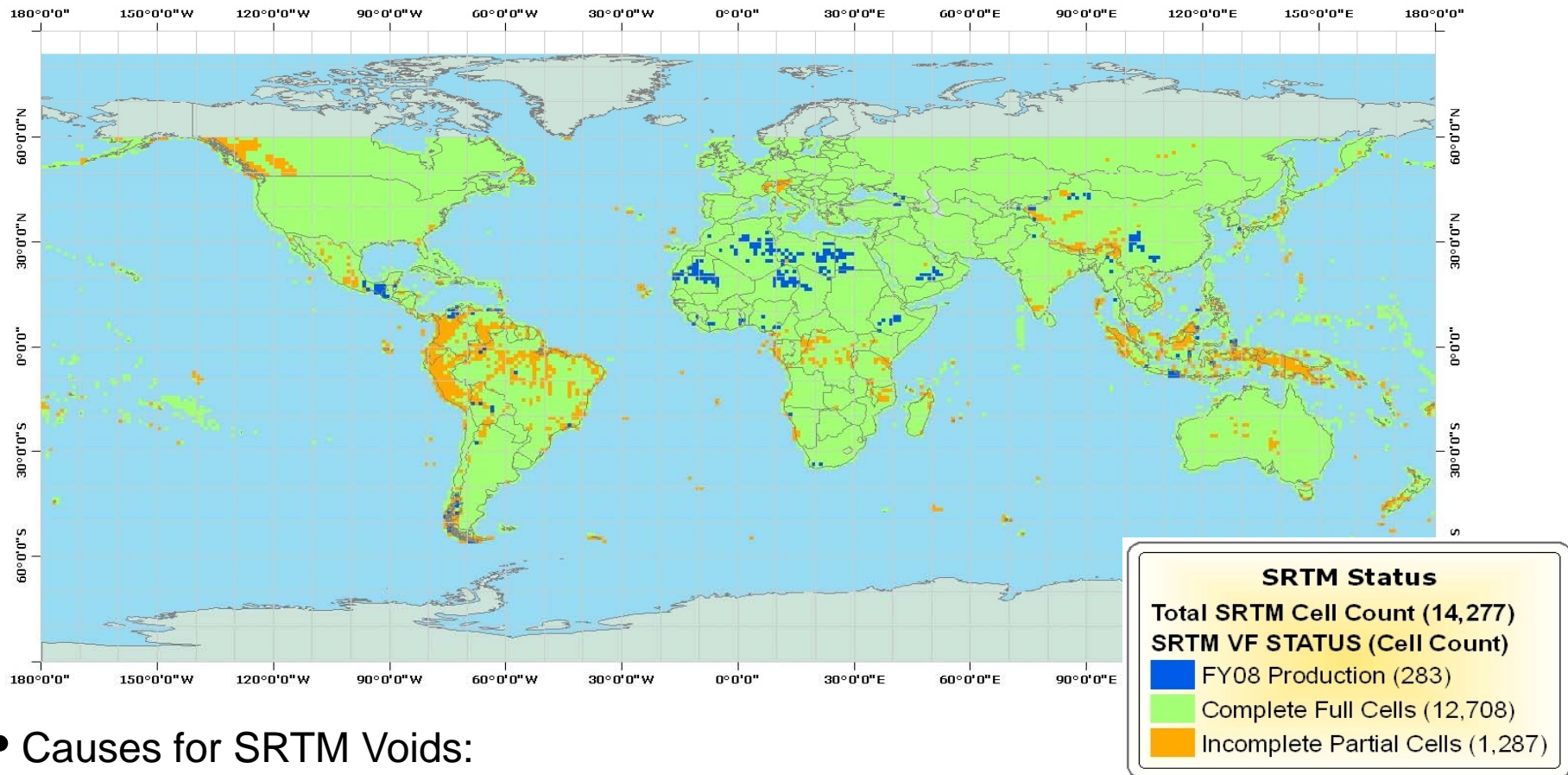


# Global Digital Elevation Replacement Project

- 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



# 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



# 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 using ASTER GDEM as source
  - Uses ASTER GDEM as source for 60° N to 83° N



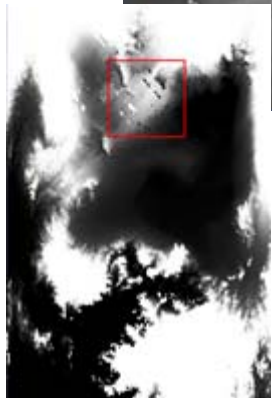
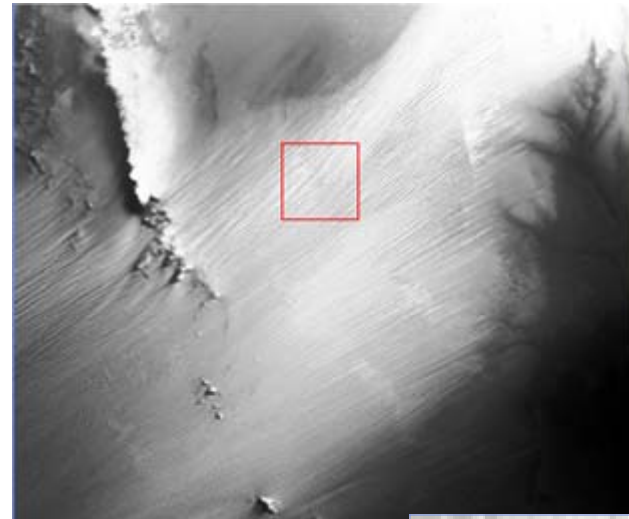
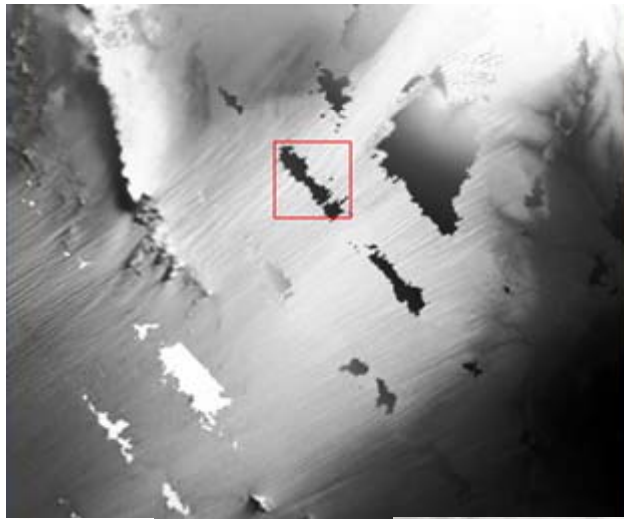
# New DEM

- 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
  - Being used 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

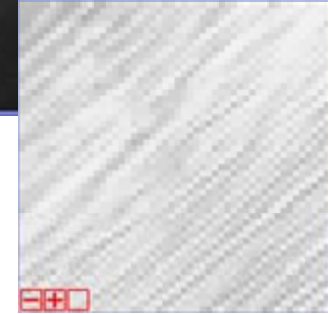


# Old vs. New DEM

MODIS Geolocation Height (data-day 2010/221)



Original DEM  
(C5)



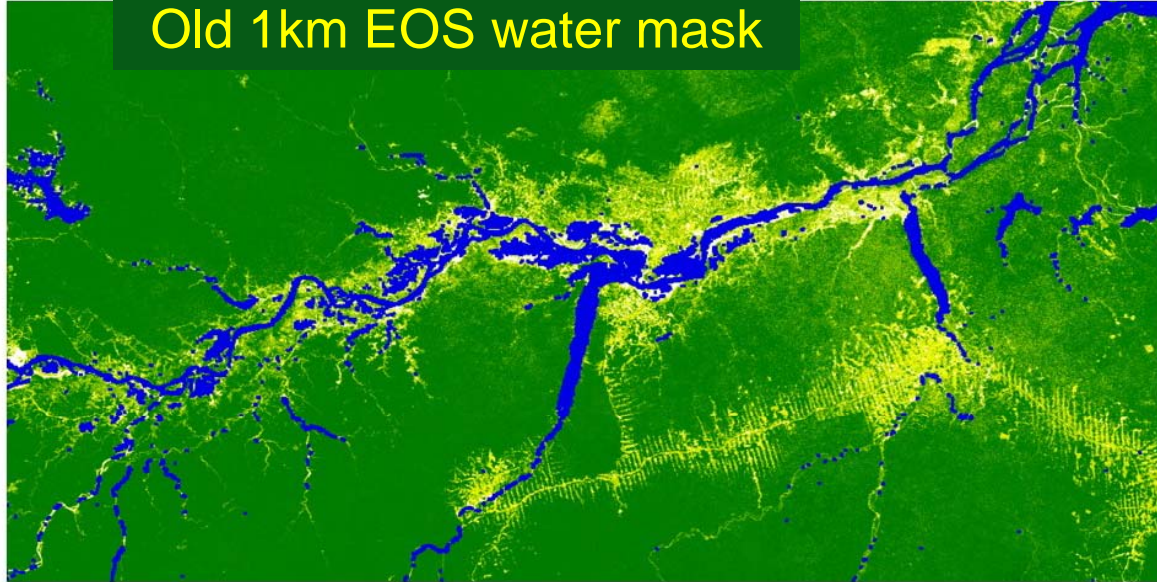
New DEM  
(C6)



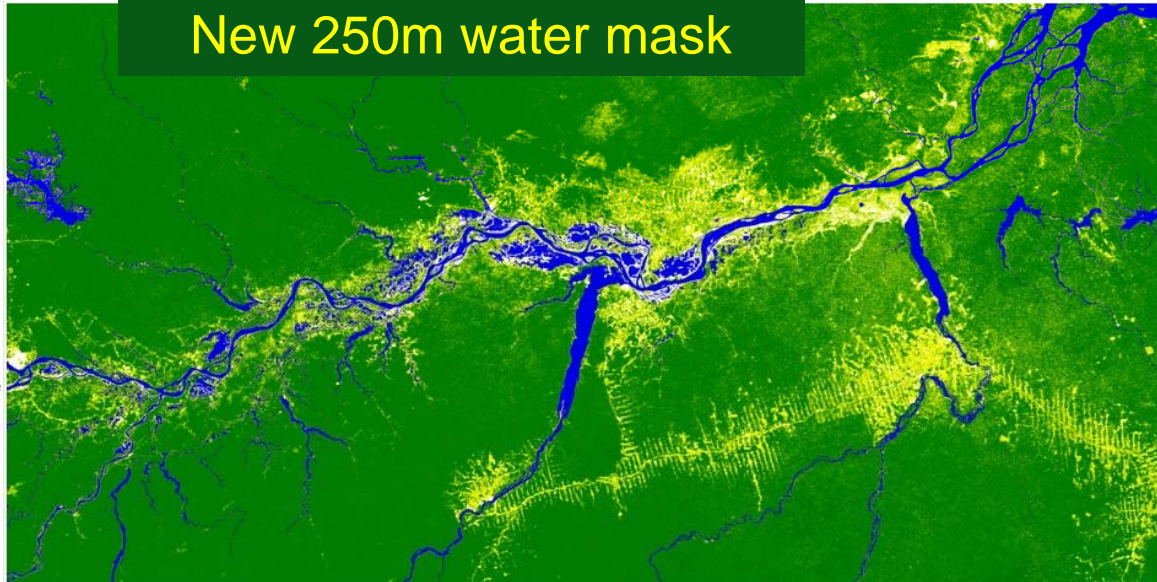


# New Land/Water Mask for C6

Old 1km EOS water mask



New 250m water mask





## New Land Water Mask in C6 MOD03

- 1km Land Water mask derived from the original 500m resolution LW Mask provided by UMD.
- More accurate than C5 and contains fine details
- Includes same 7 classes as in C5
- Includes new dataset "Water Present"
  - Indicates the total weight of all high resolution water pixels that were aggregated into the low resolution Land/Water mask



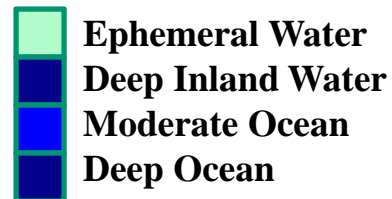
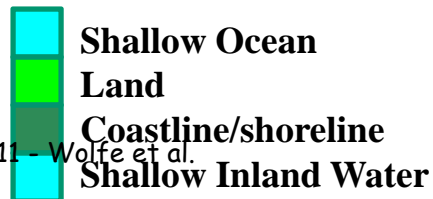
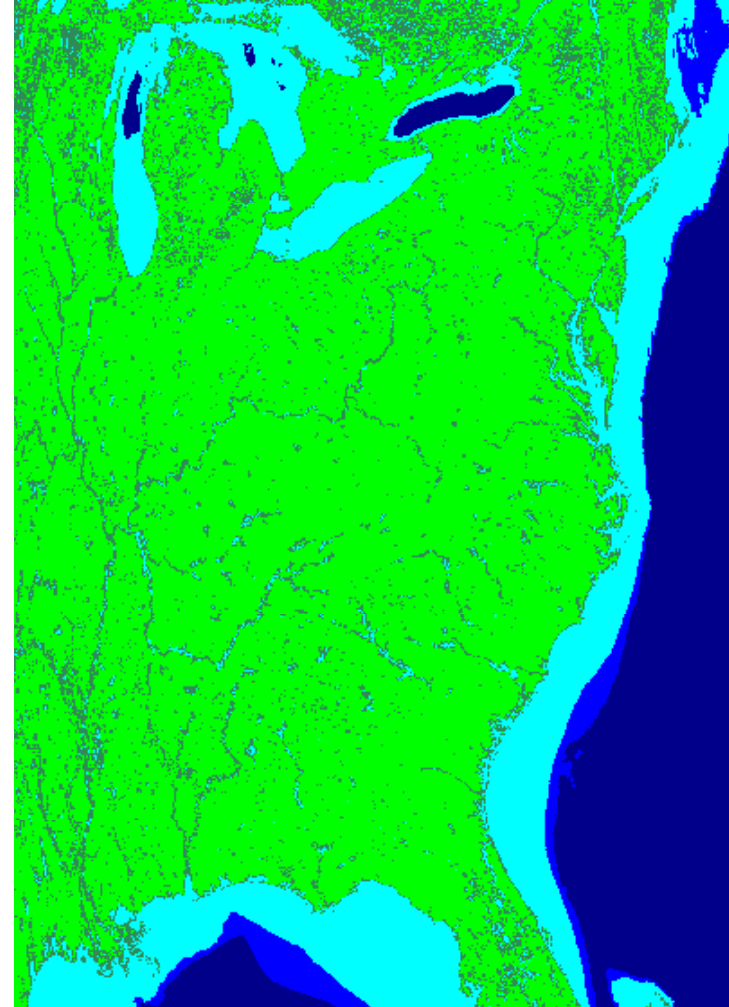
# New Land Water Mask in C6 MOD03

Terra Granule 16:20, Day 2003-193

C5



C6



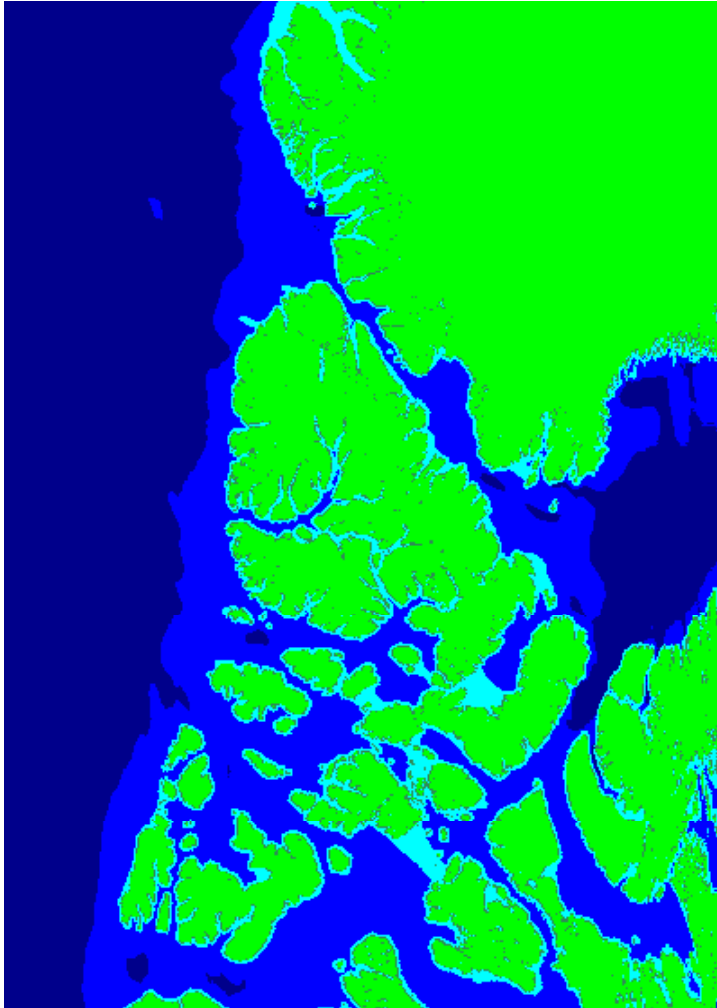
May 17, 2011 - Wolfe et al.



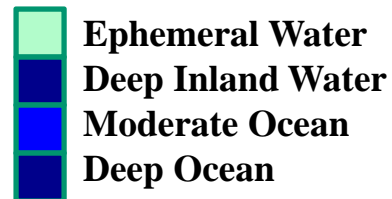
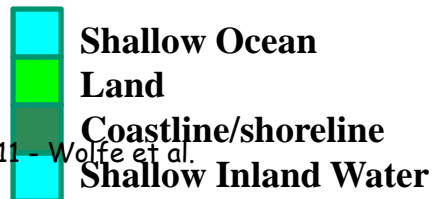
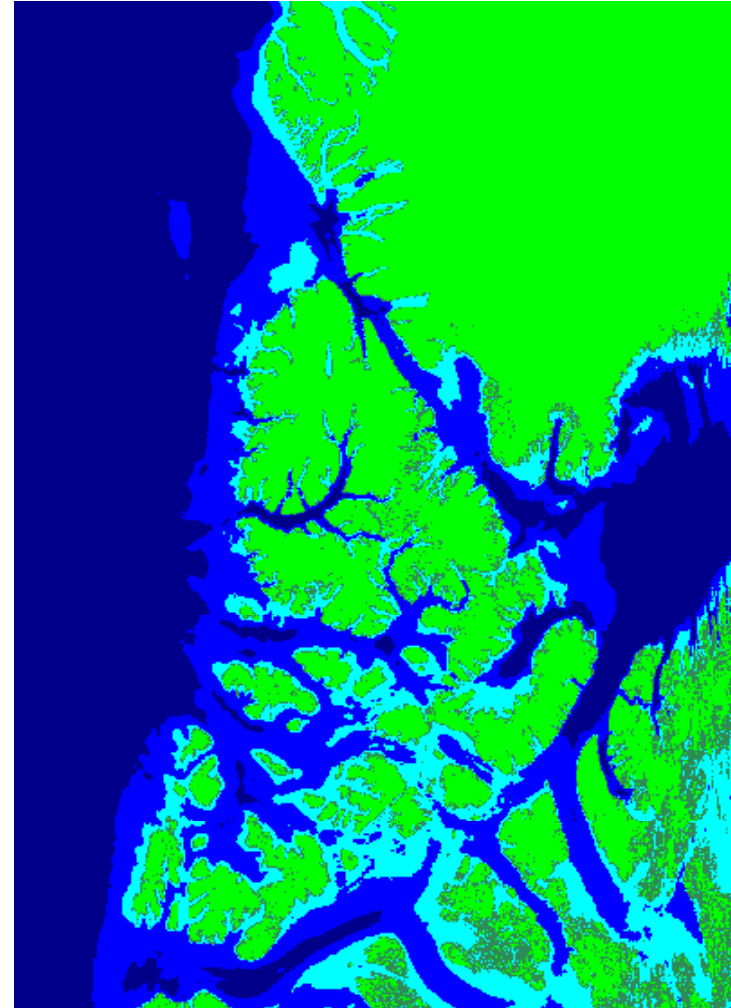
# New Land Water Mask in C6 MOD03

Terra Granule 19:25, Day 2003-193

C5



C6

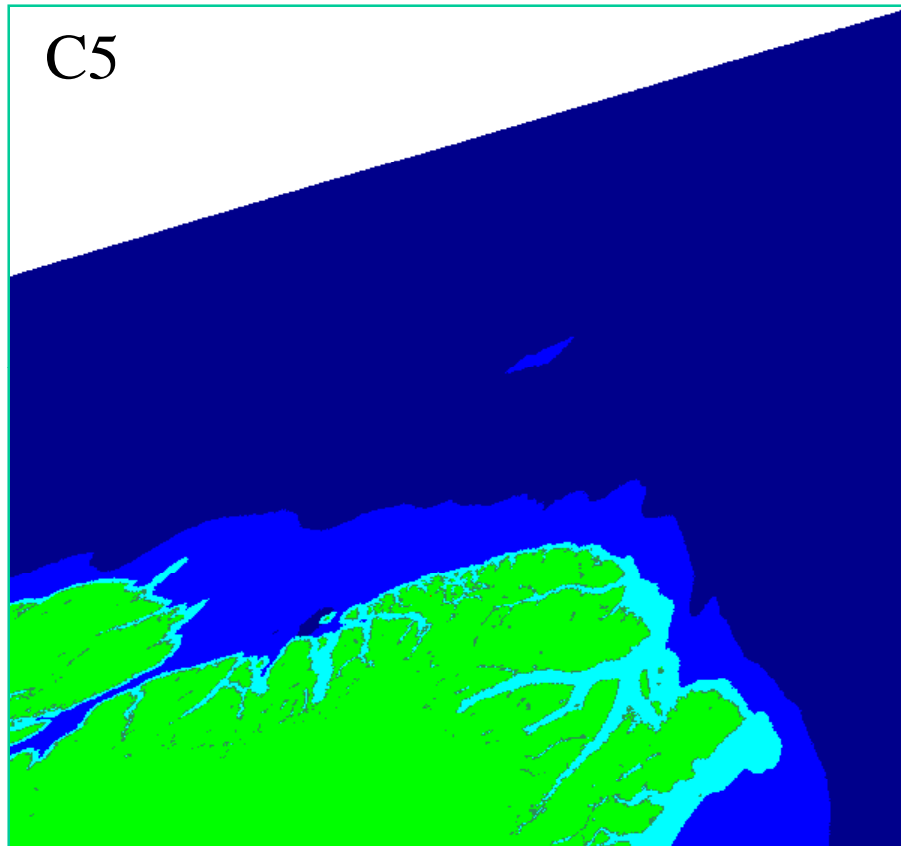


May 17, 2011 - Wolfe et al.

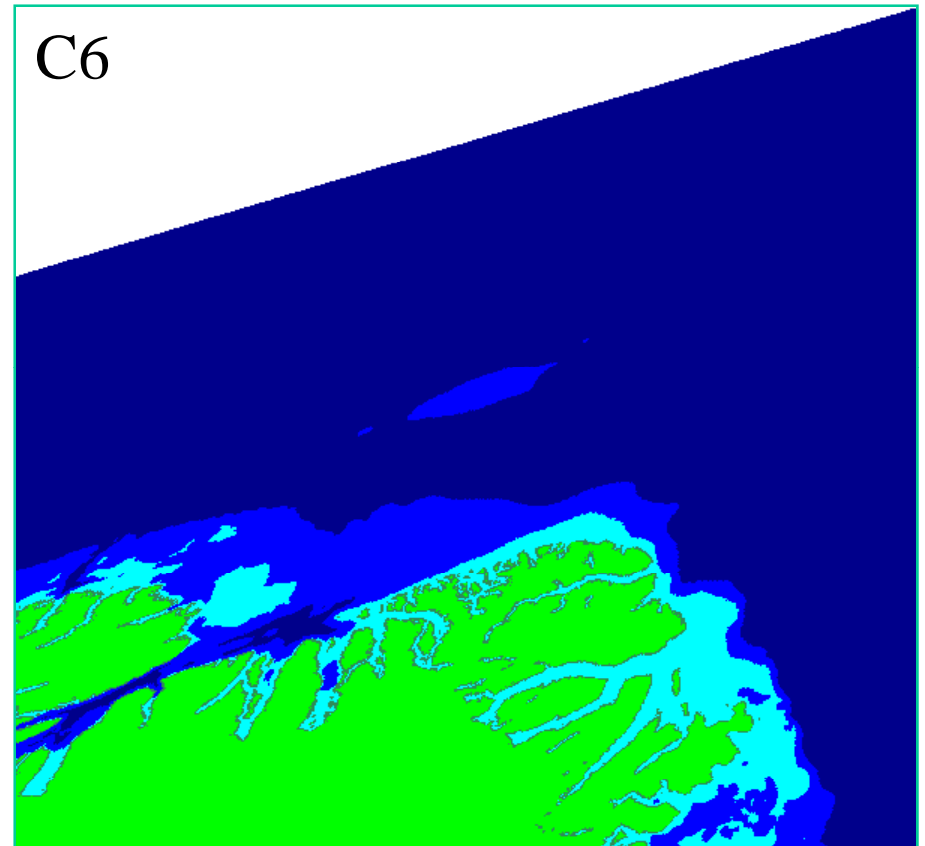


# New Land Water Mask in C6 MOD03

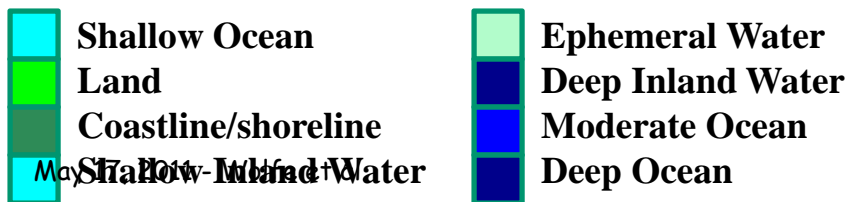
Fixed error in C5 LW Mask at high Latitude: Tile h17V00, Day 2003-193



From C5 MOD09A1 using C5 MOD03



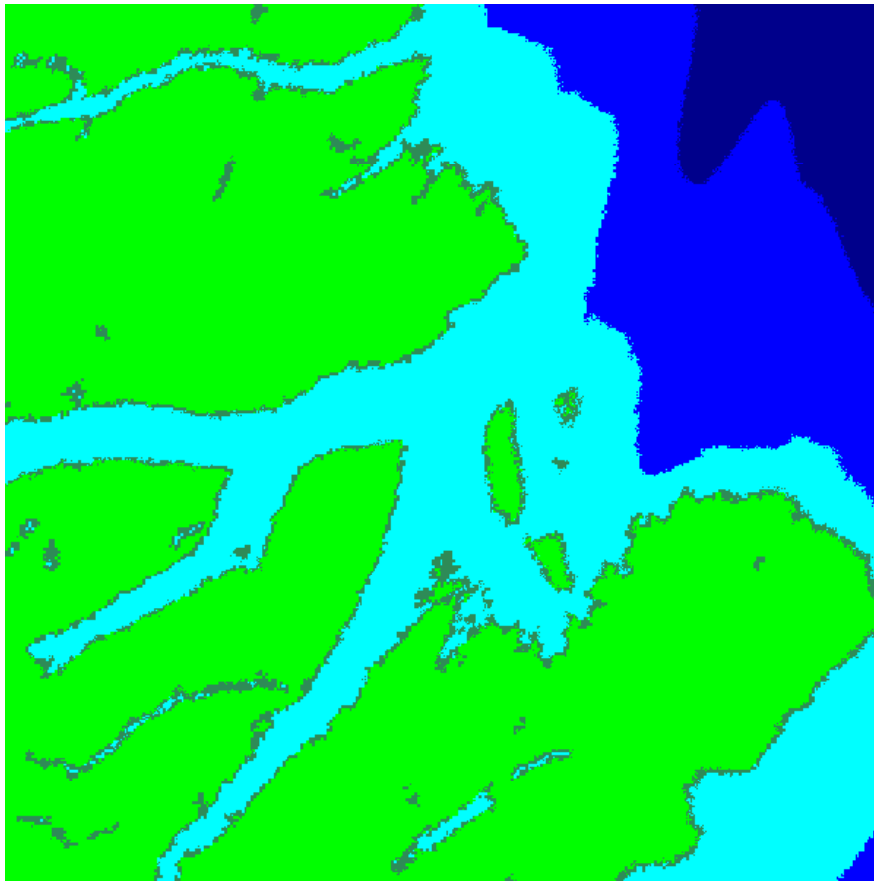
From C5 MOD09A1 using C6 MOD03



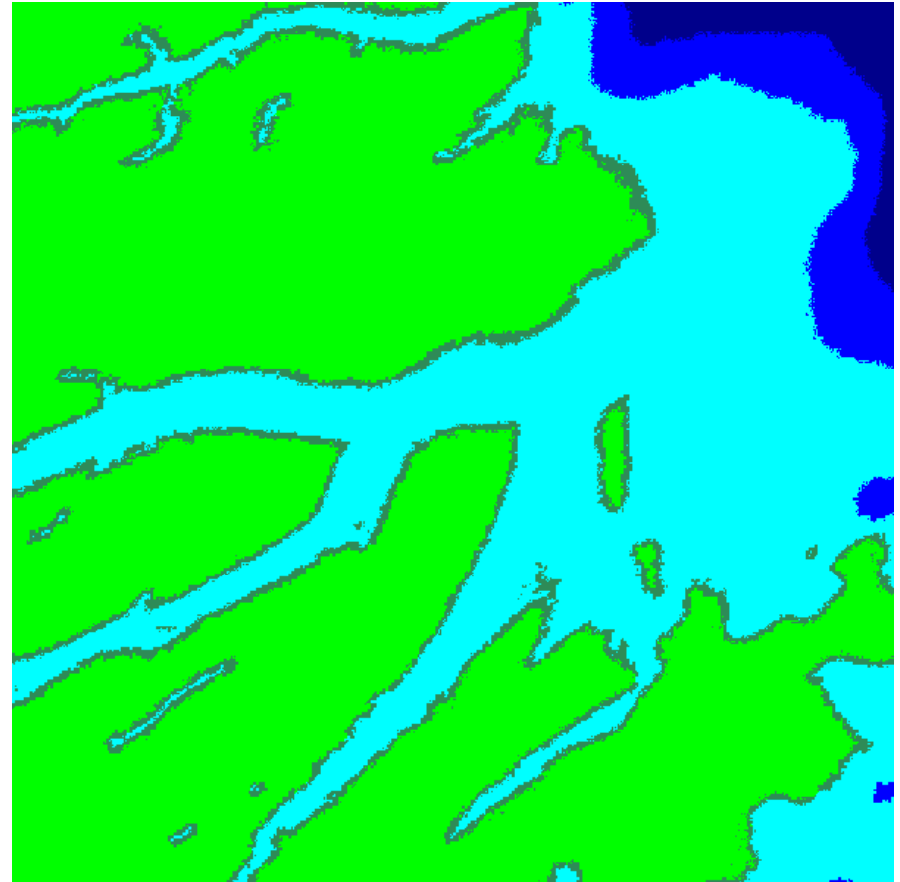


# New Land Water Mask in C6 MOD03

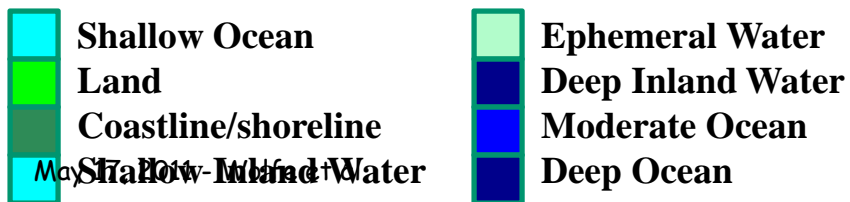
Fixed error in C5 LW Mask at high Latitude: Tile h17V00, Day 2003-193



From C5 MOD09A1 using C5 MOD03

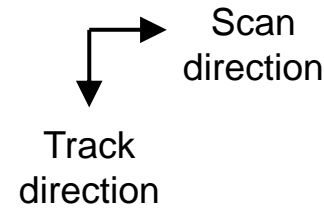
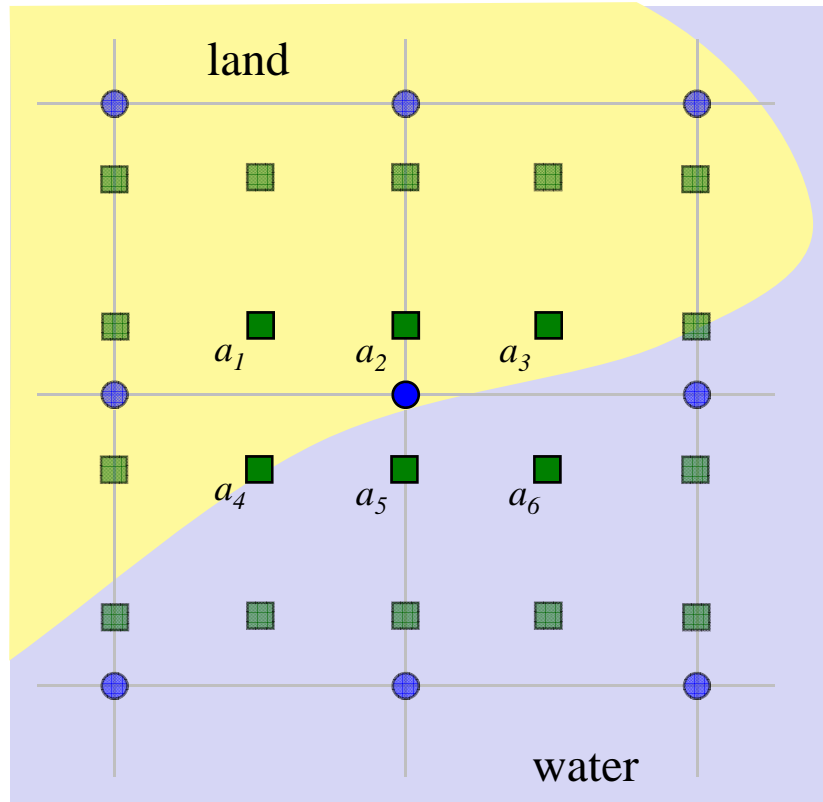


From C5 MOD09A1 using C6 MOD03





# Water present method



- — 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

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

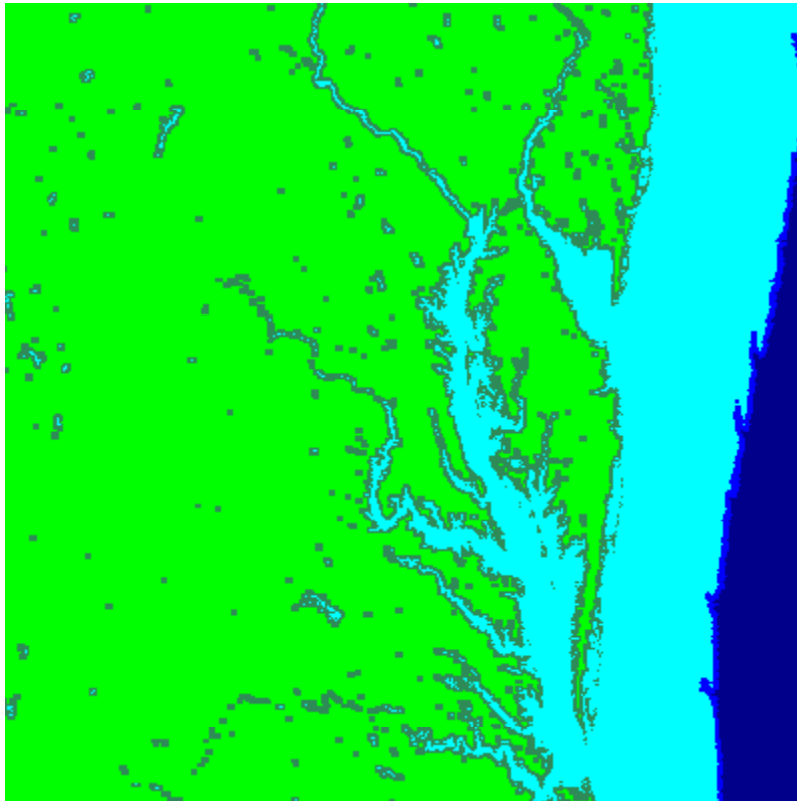
These weights approximate the **triangular** time-integrated weighting function in the **scan** direction and the **rectangular** weighting function in the **track** direction.



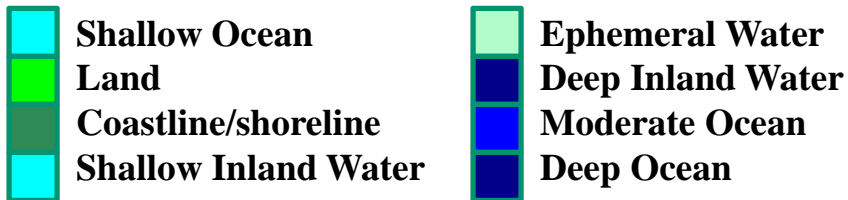
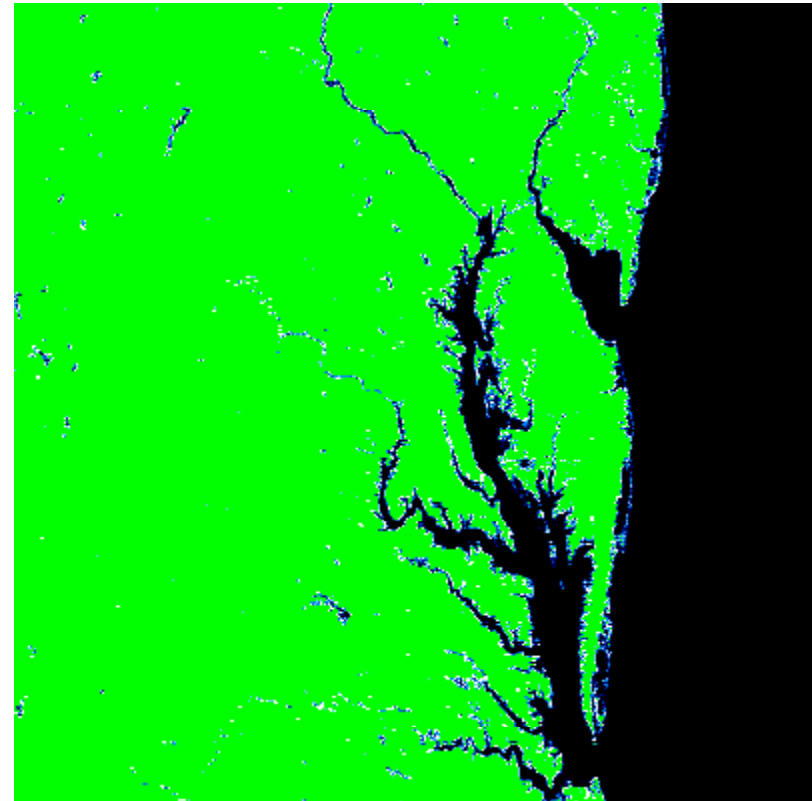
# New Land Water Mask in C6 MOD03

Spatial Subset from Terra Granule 16:20, Day 2003-193

## Land Water Mask



## Water Present



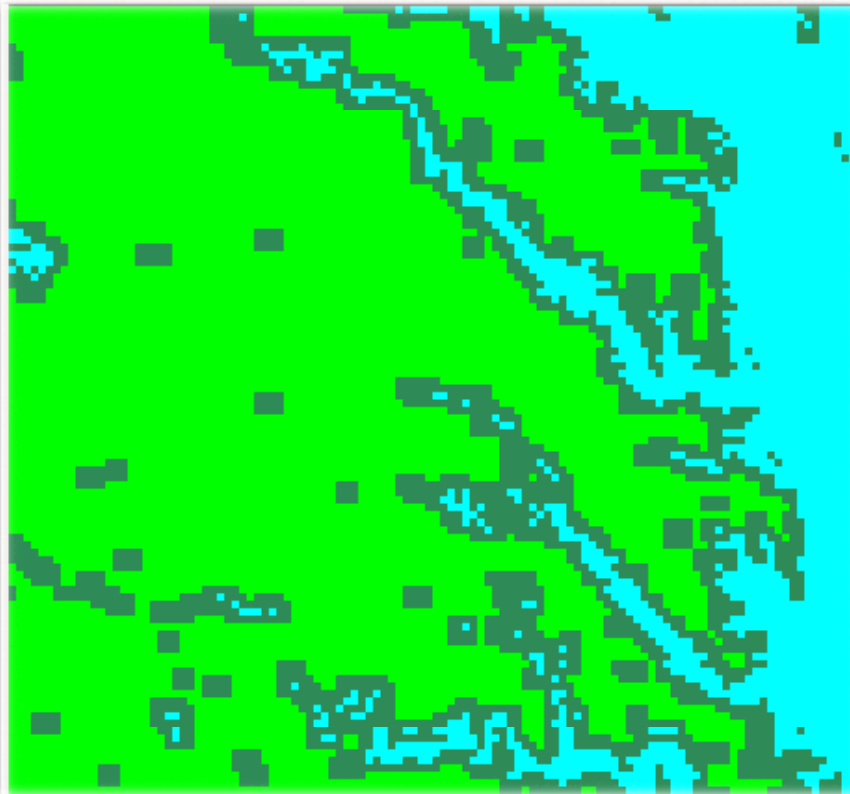




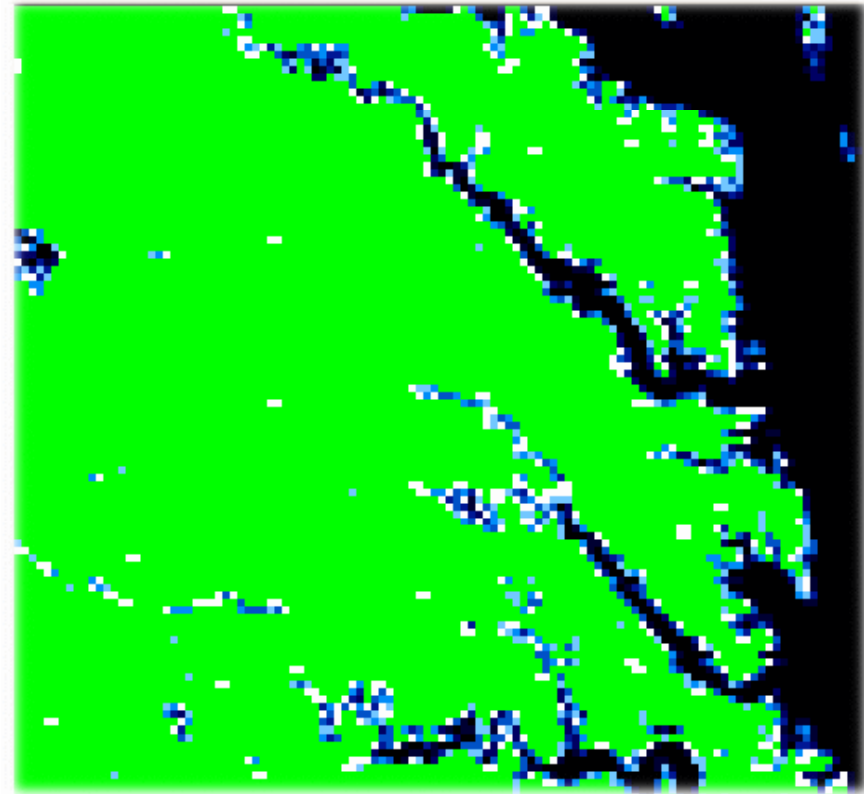
# New Land Water Mask in C6 MOD03









Spatial Subset from Terra Granule 16:20, Day 2003-193

## Land Water Mask



## Water Present



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





# 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 Land/water mask developed by UMD
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 (in conjunction with VIIRS Geolocation activity)



# Planned C6 Changes (2 of 2)

## Other Changes

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