Jason 2 Non-Conservative Force Modeling

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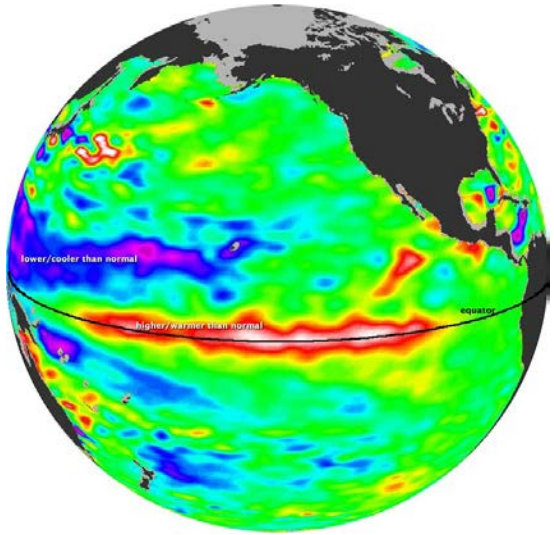
Jason 2

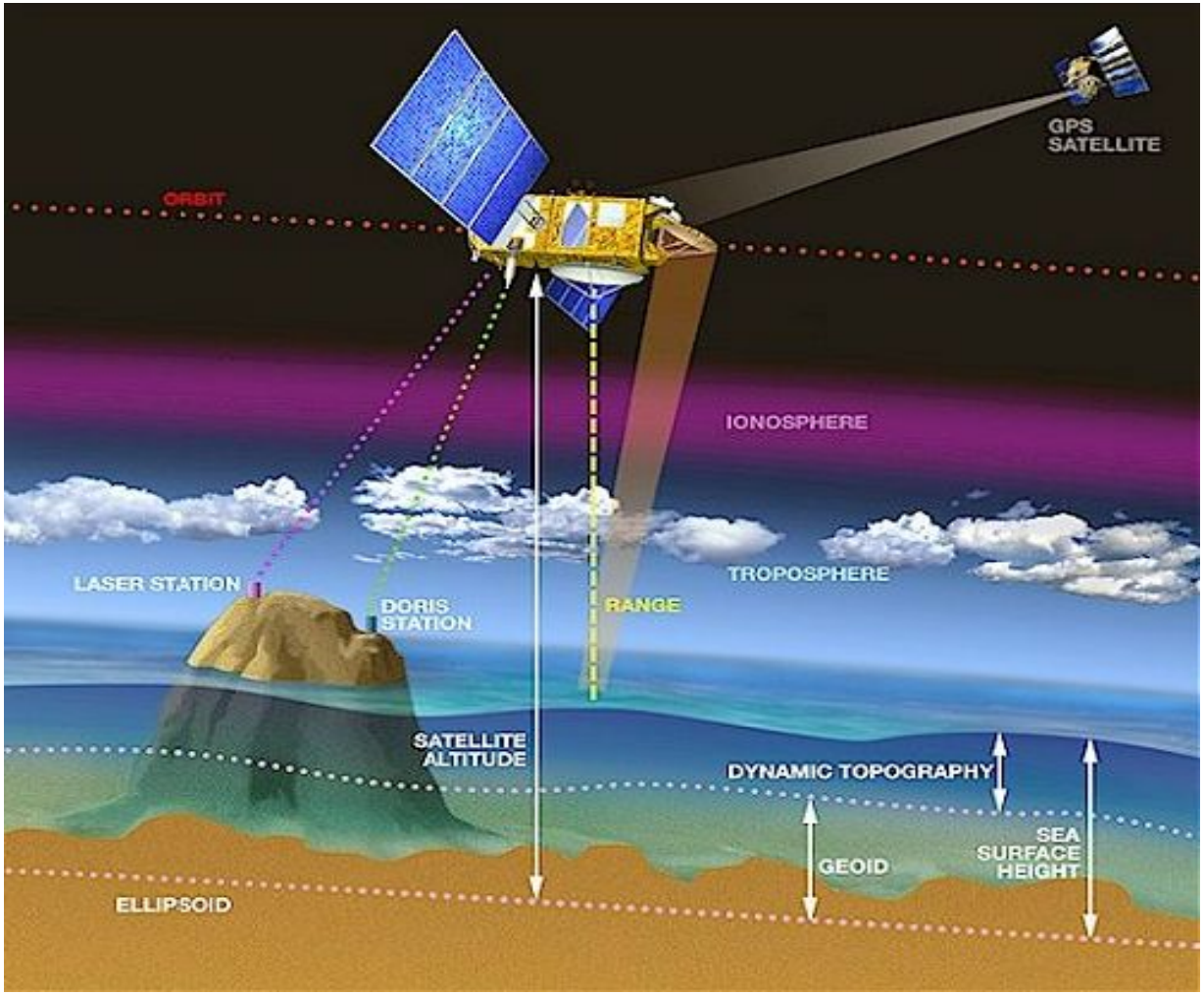
- Continuation of TOPEX/Posseidon and Jason 1
- Sea surface height measurements
- Ocean Circulation
- Applications in study of climate change
- Weather prediction – Hurricane forecasting

Precise Orbit Determination (POD)

- Orbit must be known precisely
  - Sea surface height measurements are sensitive to satellite location
- In-depth modeling of the system is required
- Many effects influence orbit
  - Gravity
  - Radiation Pressure (10^{-9})
  - Atmospheric Drag (10^{-10})
  - Antenna Recoil (10^{-12})

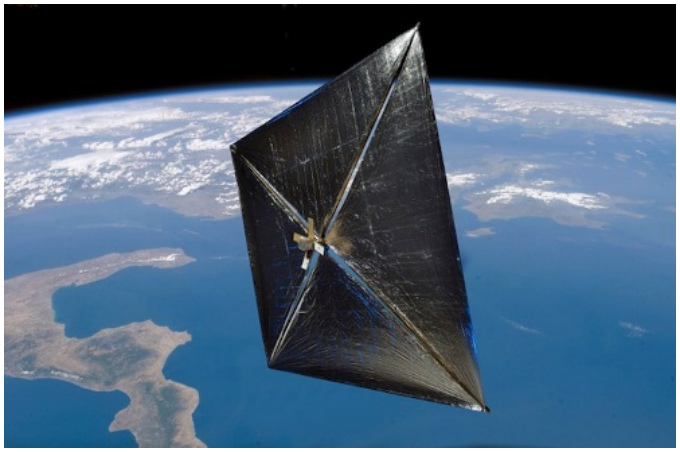


POD Diagram


GPS SATELLITE
ORBIT
IONOSPHERE
TROPOSPHERE
LASER STATION
DORIS STATION
RANGE
SATELLITE ALTITUDE
DYNAMIC TOPOGRAPHY
GEOID
SEA SURFACE HEIGHT
ELLIPSOID

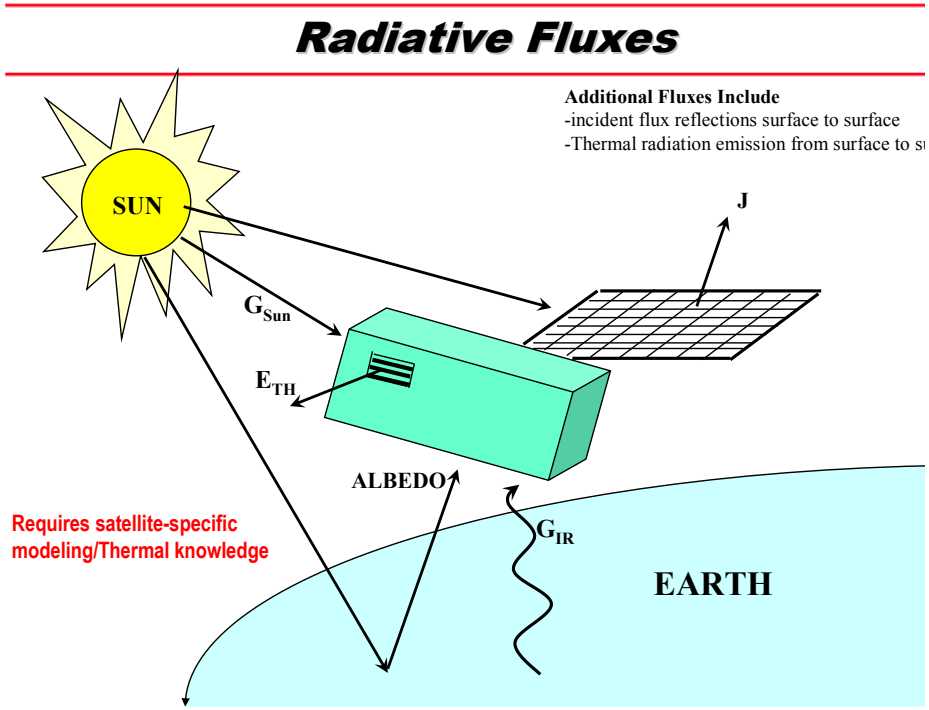
Radiation Pressure

- Photons striking a surface exert a pressure
- Photons emitted by Sun and Earth
- Albedo
- Accurate 3D model of satellite needed



NanoSail-D2

Macro Model



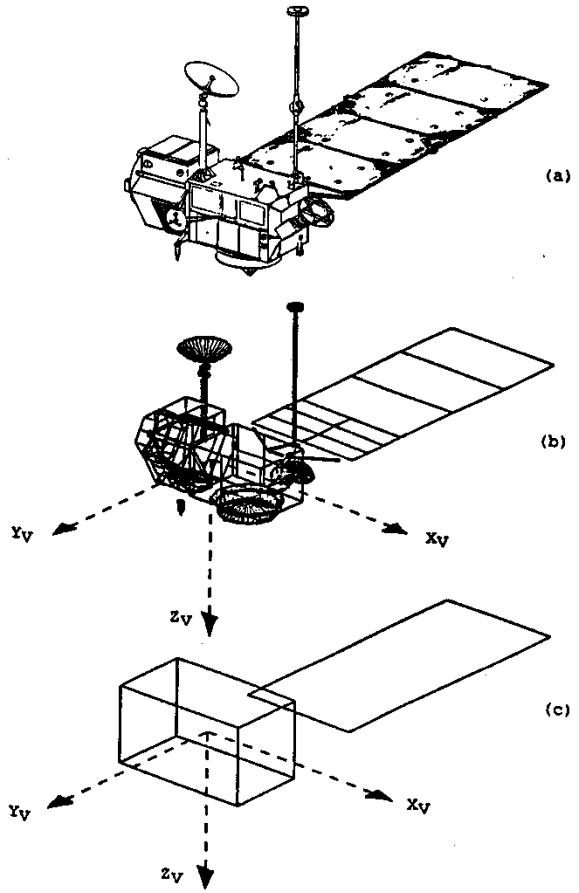
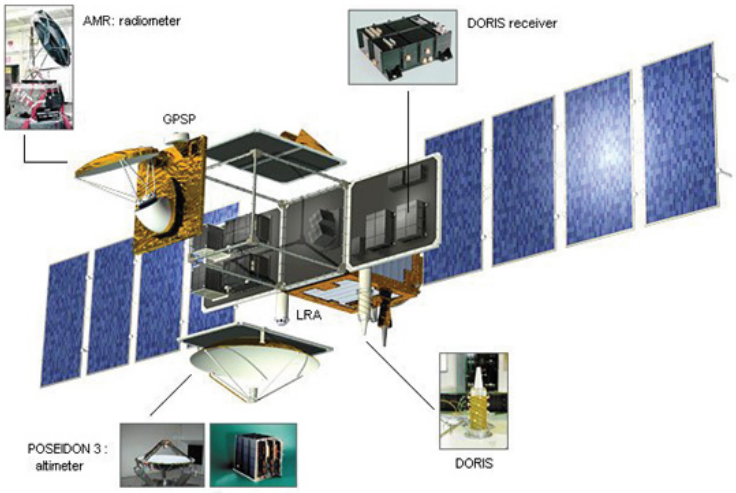


Figure 1. (a) The TOPEX/Poseidon Spacecraft, (b) Micro-Model Approximation, (c) Macro-Model Approximation

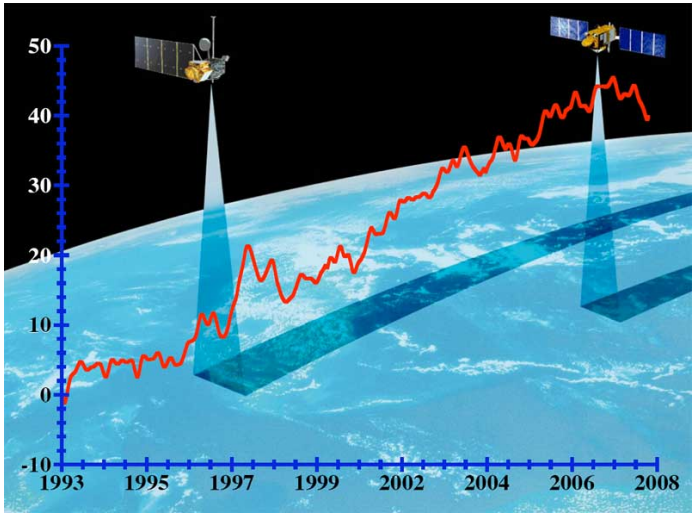
Changes in Macro Model

- Jason 2 previously modeled with one panel
- New model has two solar panels
- CNES data includes panel orientation
- Improves orbit determination
  - Solar radiation pressure
  - Atmospheric drag

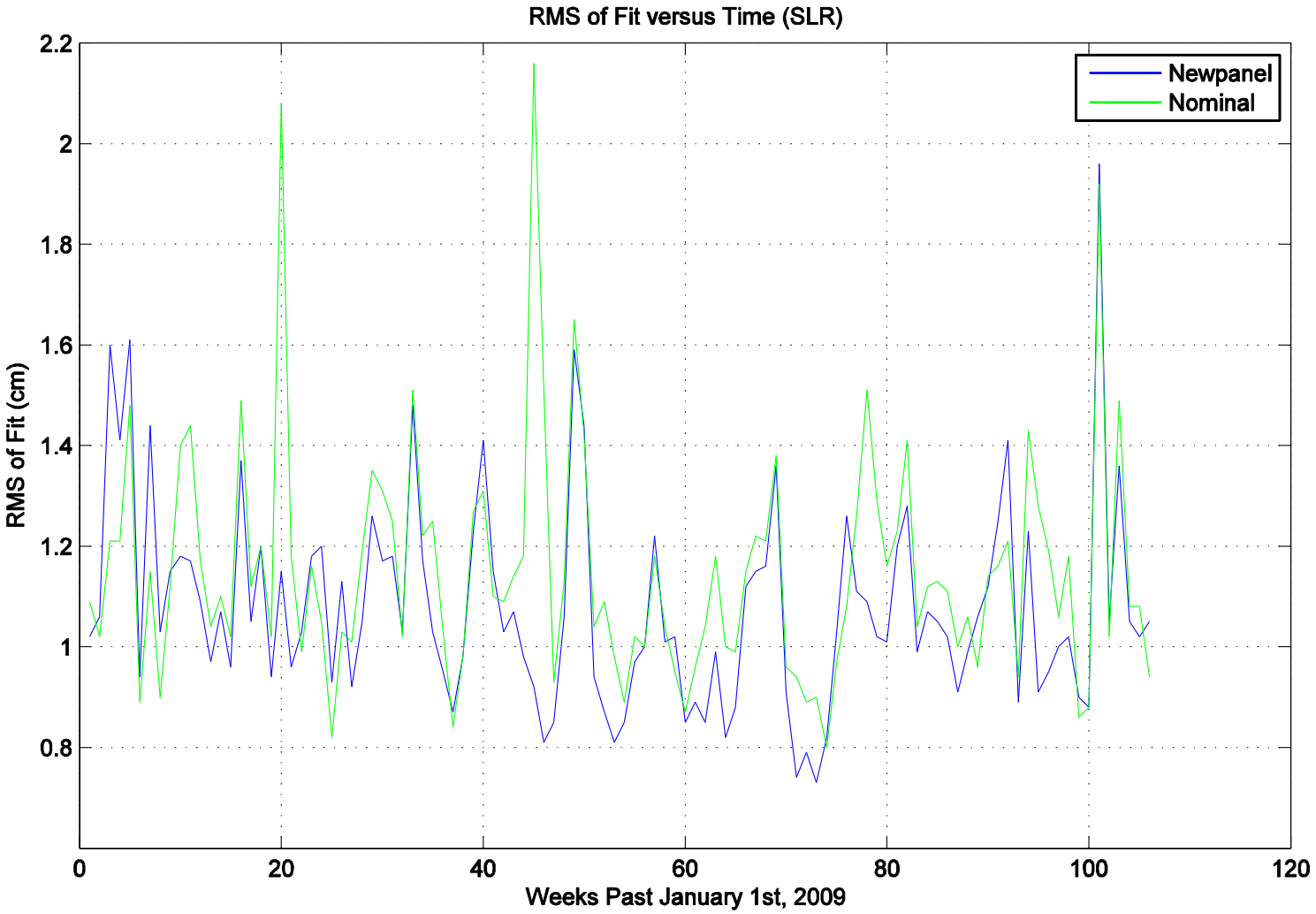


Verifying New Model

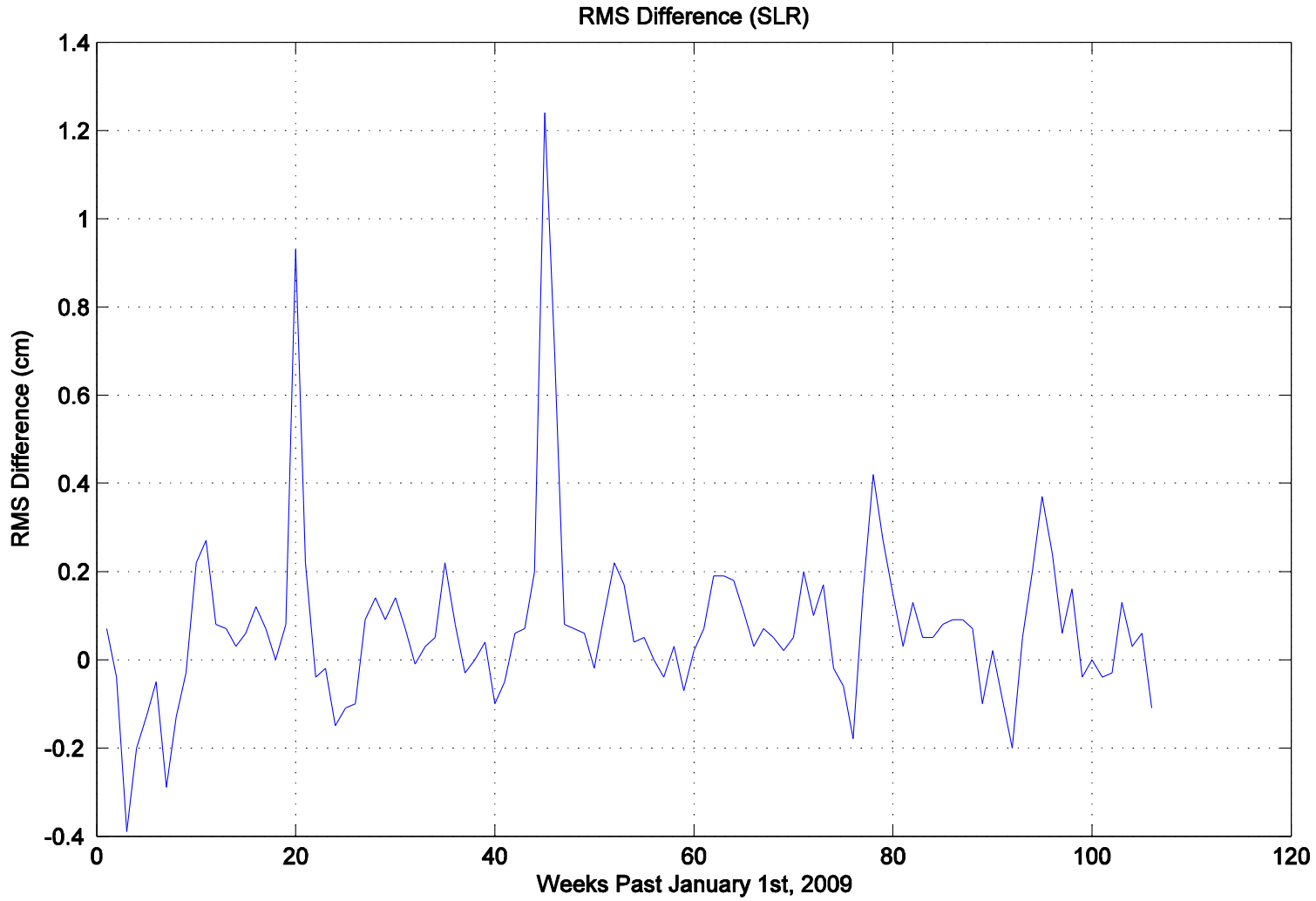
- New model must be tested against nominal case
- Comparison of two years of arcs (2009-2010)
- Compare RMS of fit
- Compare empirical accelerations



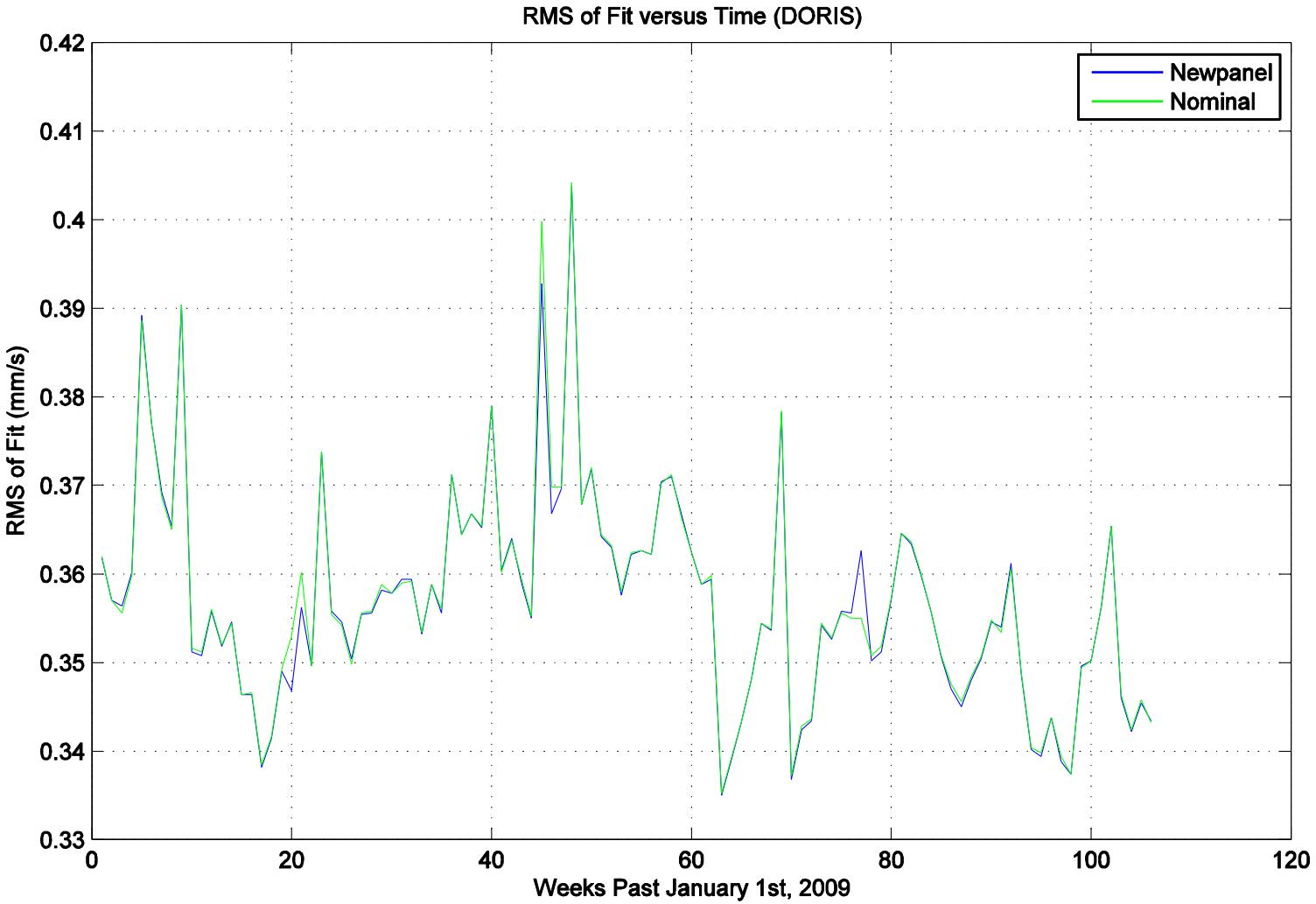
RMS (SLR)


RMS of Fit versus Time (SLR)
Newpanel
Nominal
RMS of Fit (cm)
Weeks Past January 1st, 2009
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0
20
40
60
80
100
120

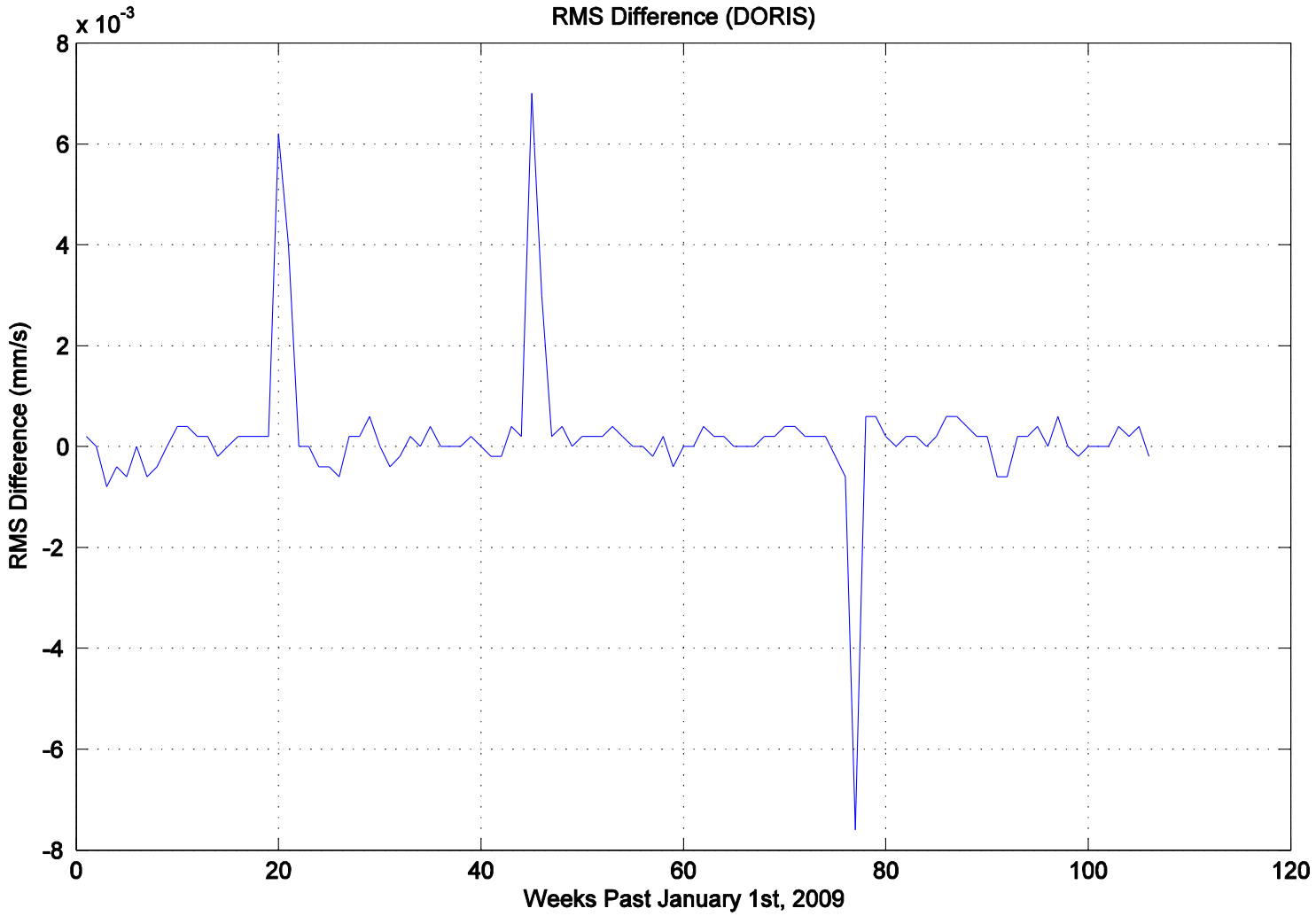
RMS Difference (SLR)



RMS (DORIS)


RMS of Fit versus Time (DORIS)
Newpanel
Nominal
RMS of Fit (mm/s)
0.42
0.41
0.4
0.39
0.38
0.37
0.36
0.35
0.34
0.33
0
20
40
60
80
100
120
Weeks Past January 1st, 2009

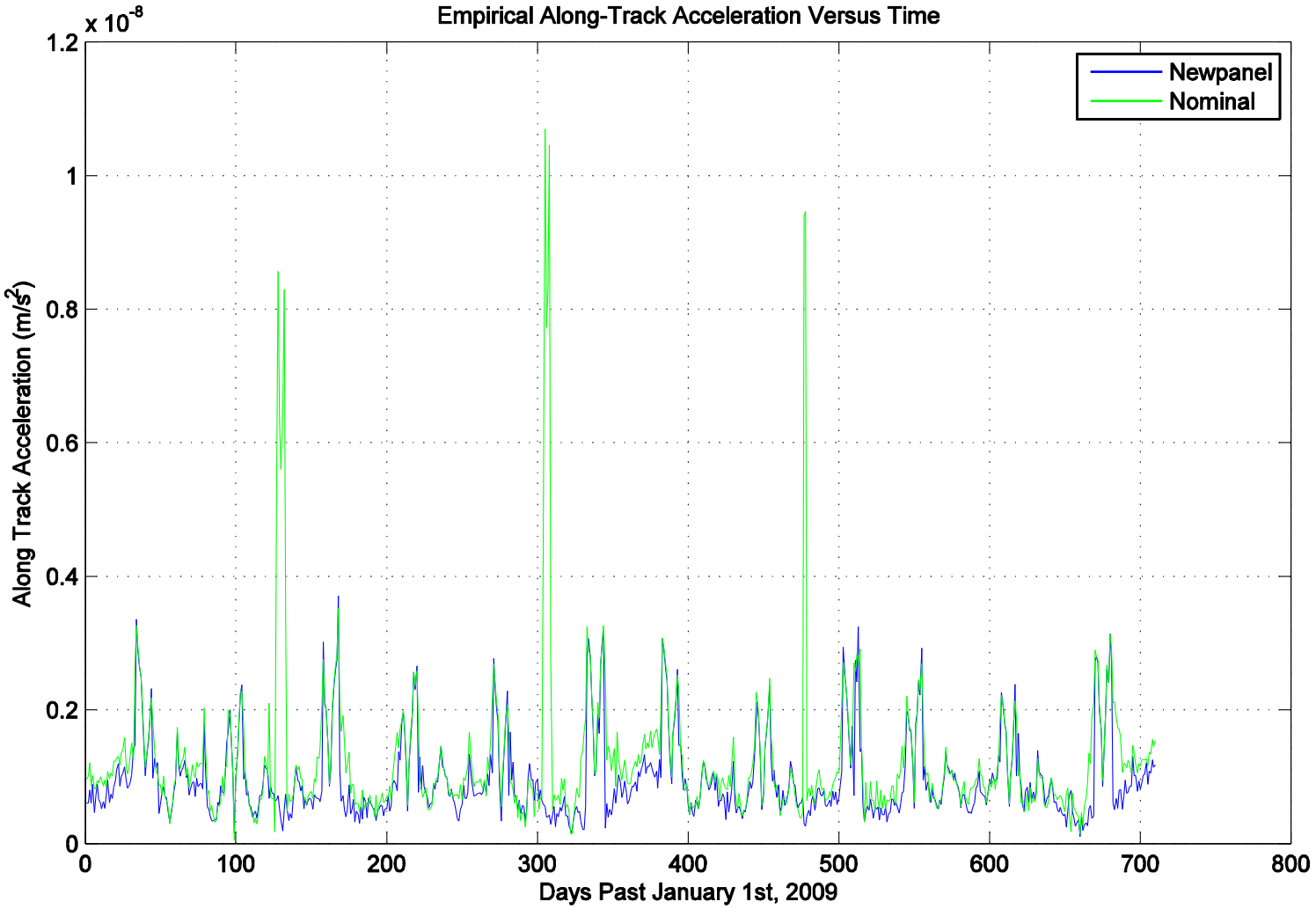
RMS Difference (DORIS)



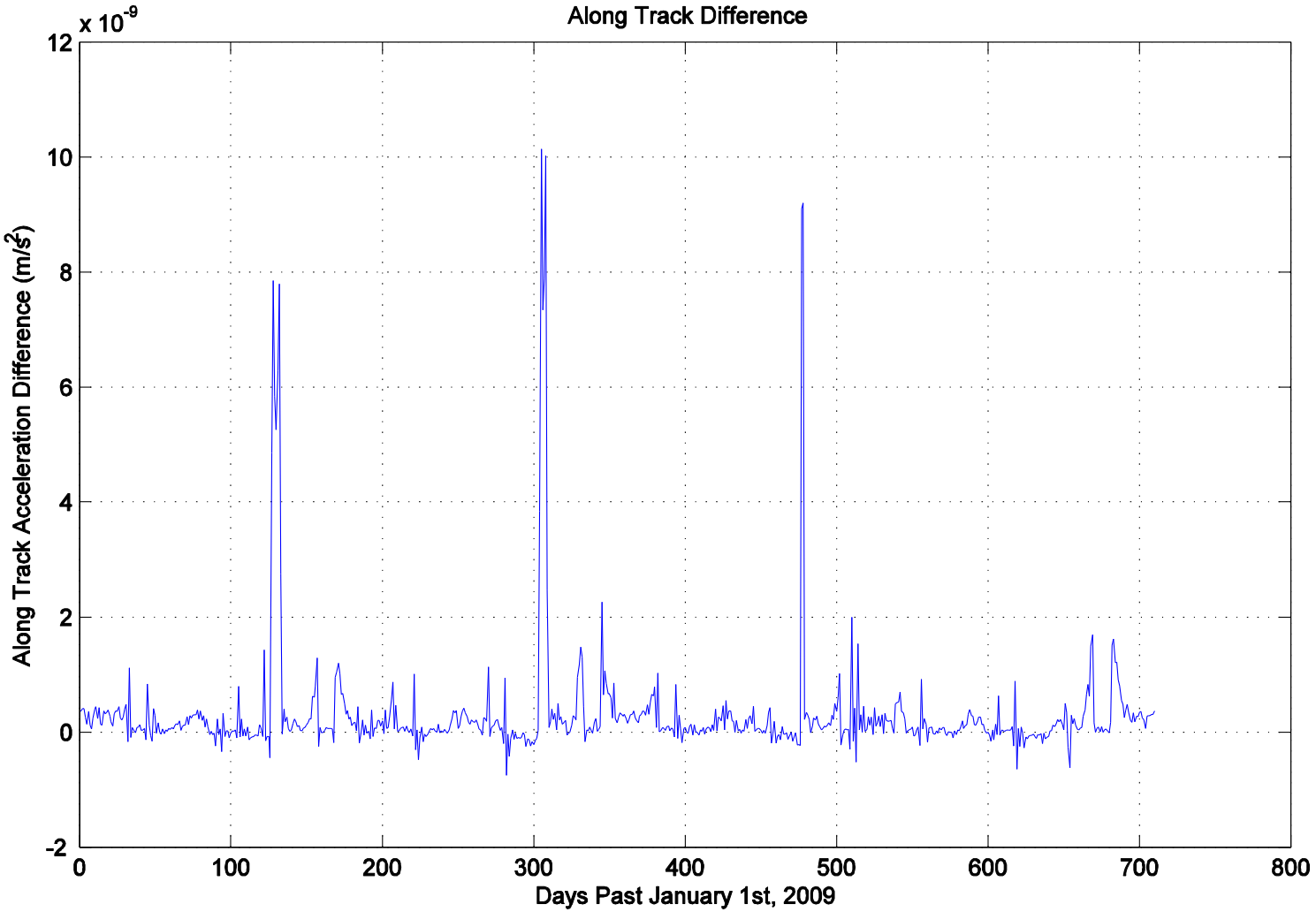
Empirical Accelerations

- Non-conservative force models are imperfect
- Used to account for small unmodeled forces
- Only possible with many observations
- Can rectify errors in model

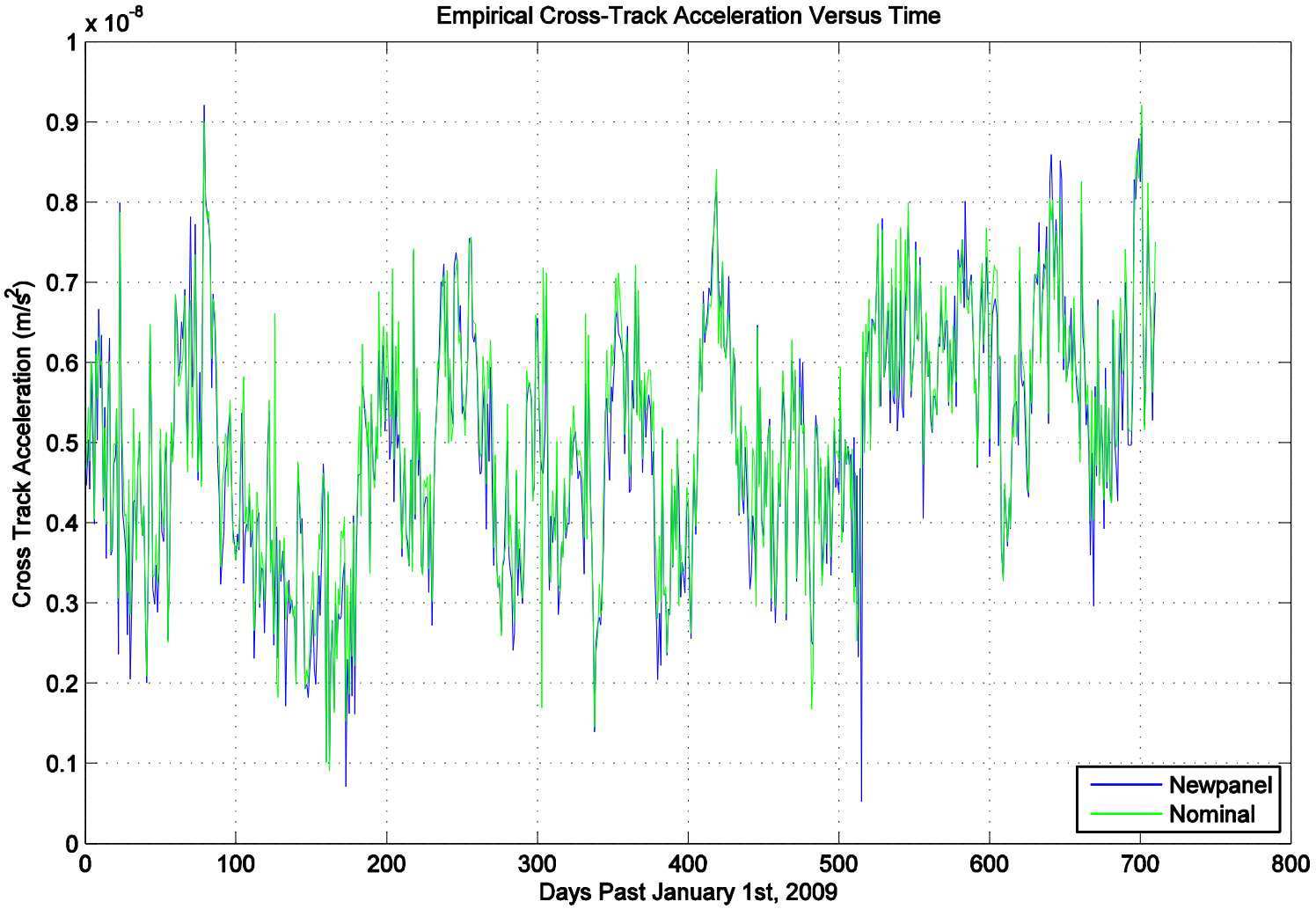
Empirical Acceleration (Along)



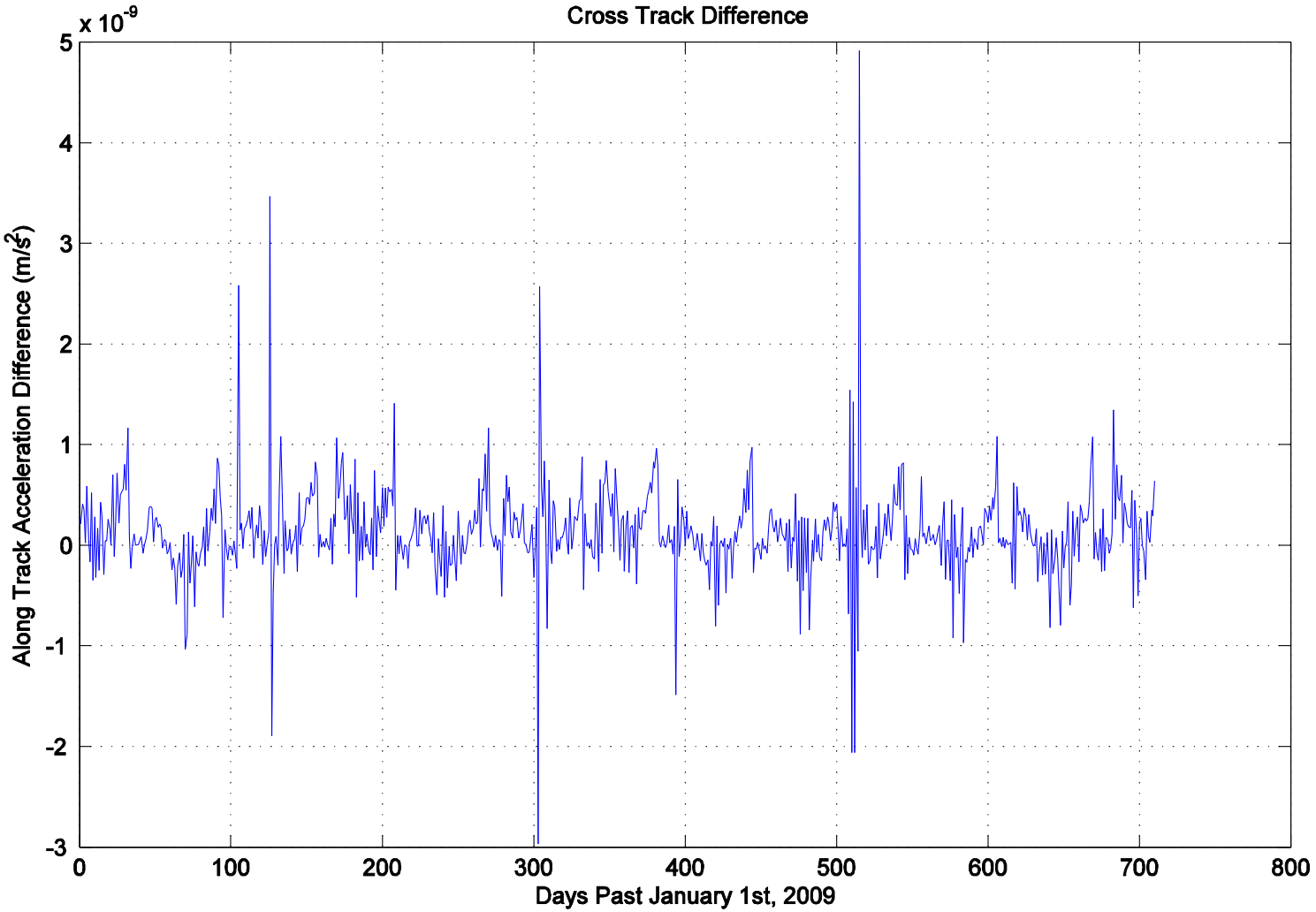
Empirical Acceleration Diff. (Along)



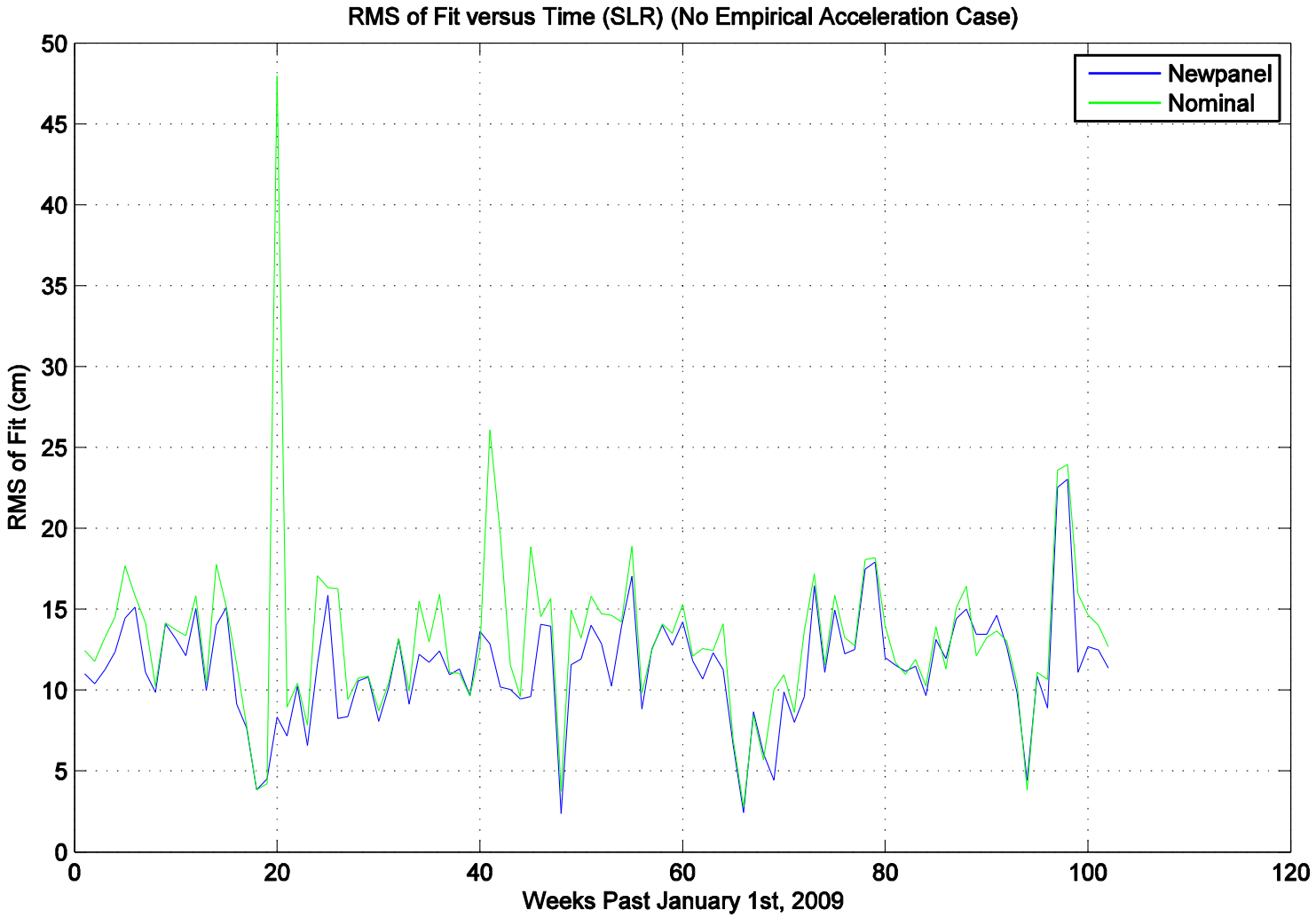
Empirical Acceleration (Cross)



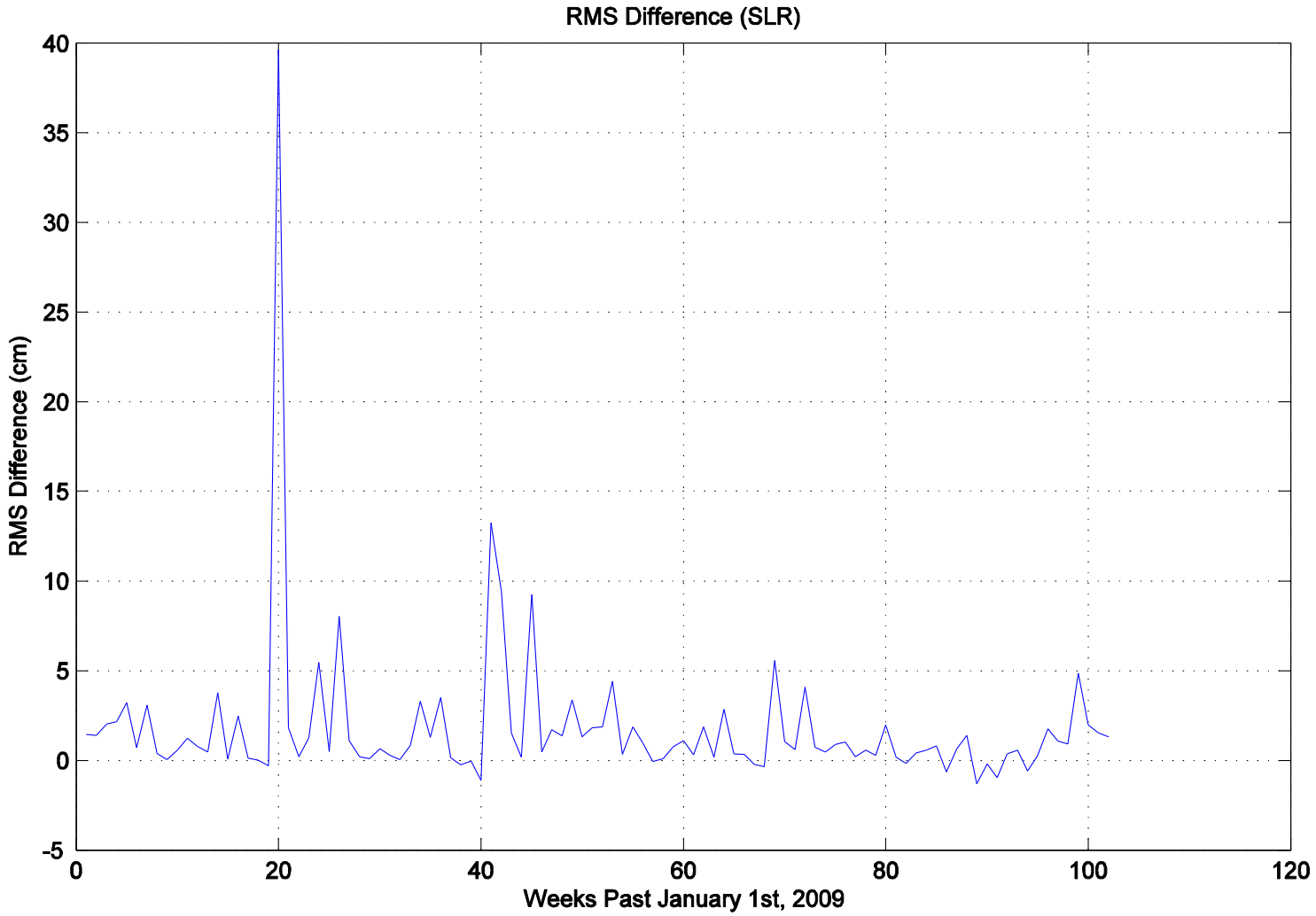
Empirical Acceleration Diff. (Cross)



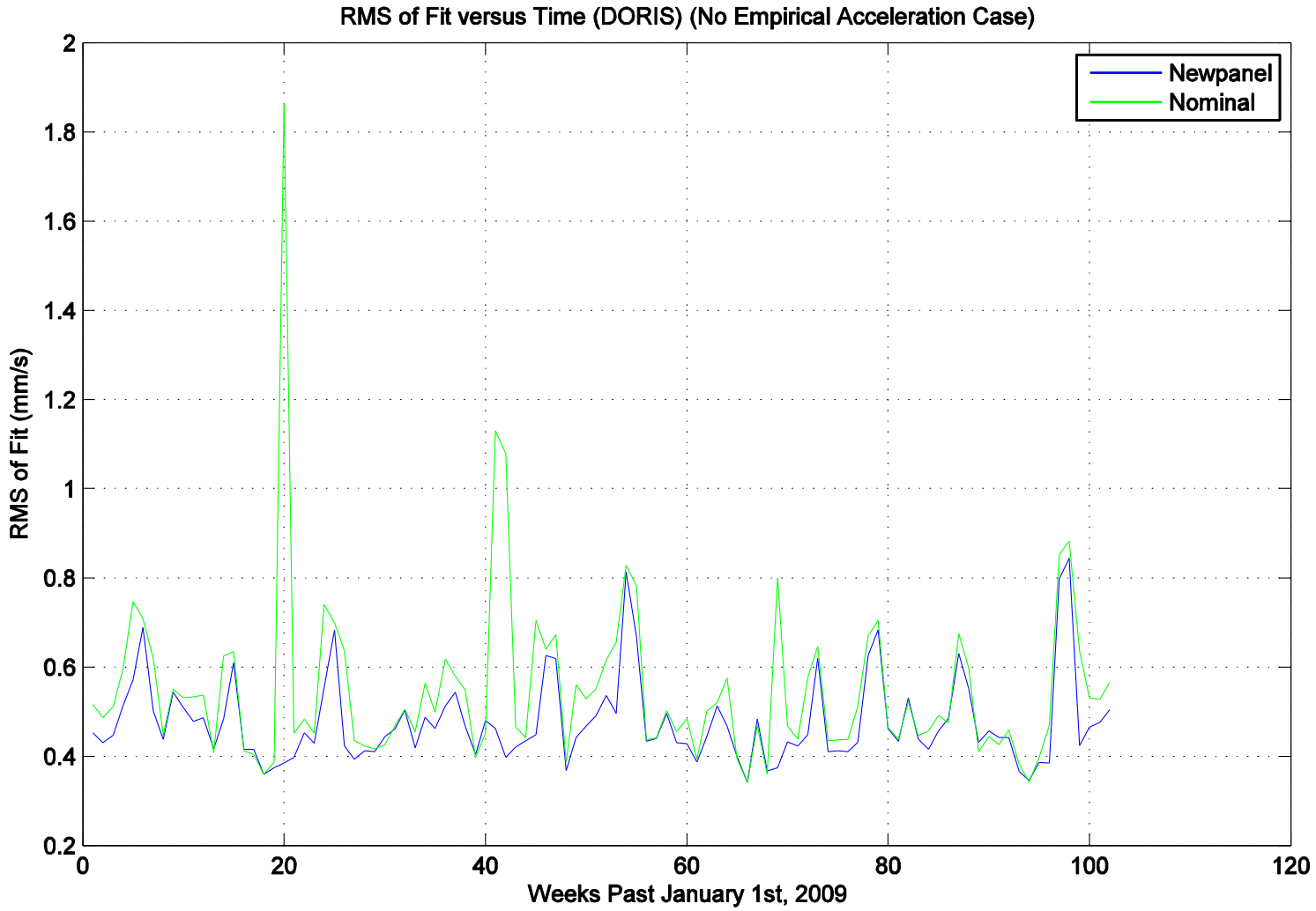
RMS (SLR)


RMS of Fit versus Time (SLR) (No Empirical Acceleration Case)
Newpanel
Nominal
RMS of Fit (cm)
Weeks Past January 1st, 2009
0
5
10
15
20
25
30
35
40
45
50
0
20
40
60
80
100
120

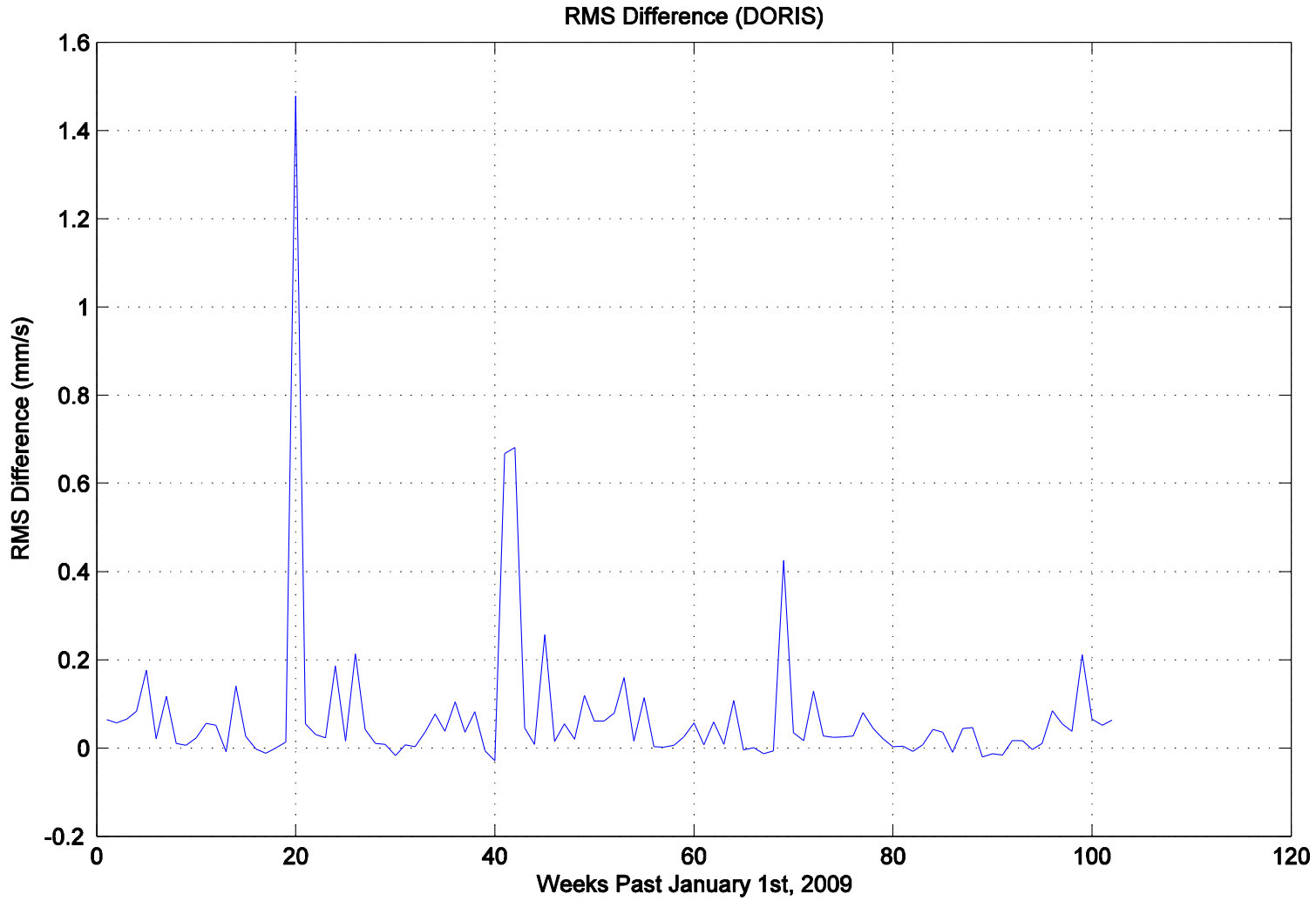
RMS Difference (SLR)



RMS (DORIS)

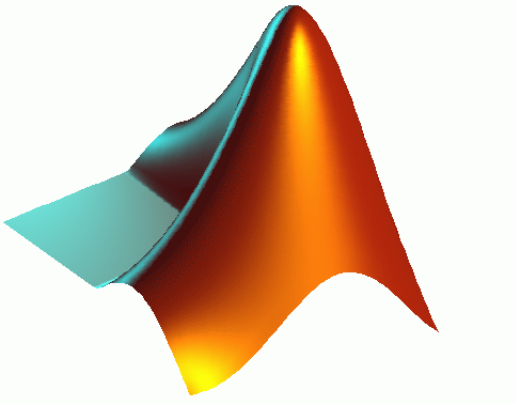

RMS of Fit versus Time (DORIS) (No Empirical Acceleration Case)
Newpanel
Nominal
RMS of Fit (mm/s)
Weeks Past January 1st, 2009
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
20
40
60
80
100
120

RMS Difference (DORIS)



Data Processing

- Quaternion and Angle Data from CNES
- MATLAB suite to concatenate files, interpolate, smooth
- FORTRAN writes out binary files, converts angles to quaternions
- GEODYN reads in attitude file, other data files
- MATLAB used to graph data



Conclusion

- POD necessary for accurate altimeter missions
- Accurate force modeling required for POD
- Requires knowledge of satellite shape and orientation
- Improvements in macro model improve POD
- Better scientific measurements