TOPEX/POSEIDON PROJECT SATELLITE/SENSORS PERFORMANCE CHARACTERISTICS WORKSHOP #10

Anomalous Force Model Status

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July 25, 2000

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Anomalous Force Modeling

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1. Least Squares Fit of Empirical Data from MOE and FDF

$$\frac{da}{dt} = \sum c_k(q)b^k + [BIAS]$$

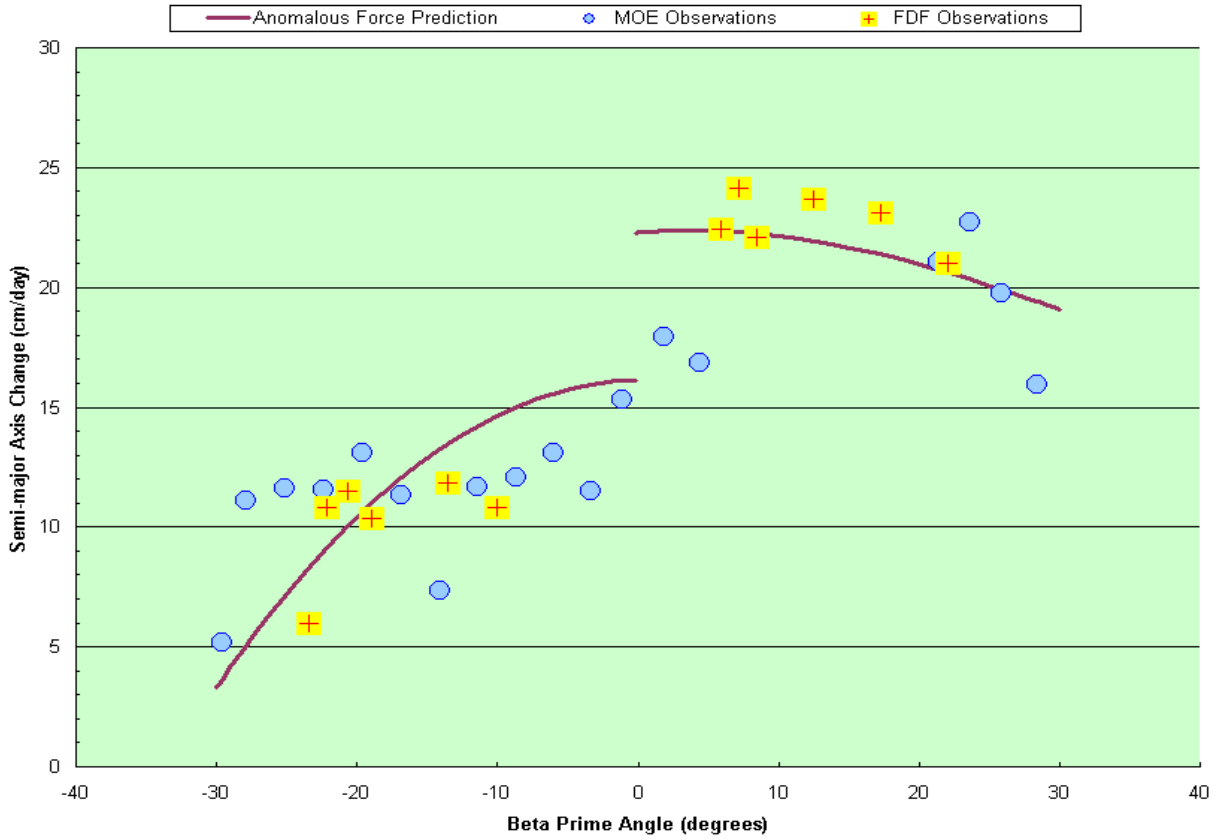
a: semi-major axis

b: angle between sun line and orbital plane

q: solar array pitch bias (magnitude and direction)

***2. BIAS* based on experience in same yaw mode and time period**

Least Squares Fit



$$\frac{da}{dt} = 16.1 + 0.0b^{1} - 0.014b^{2} - 4.4*10^{-6}b^{3} + [-3.48], (-30 \le b \le 0)$$

$$\frac{da}{dt} = 22.3 + 0.057b^{1} - 7.45*10^{-3}b^{2} + 6.6*10^{-4}b^{3} + [7.16], (0 \le b \le 30)$$

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MOE Data Conversion

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- **MOE derived accelerations (dn/dt)**
- **Conversion to semi-major axis rate of change (da/dt)**

$$\left[\frac{da}{dt}\left(\frac{\text{cm}}{\text{day}}\right)\right] = 2\sqrt{\frac{a^3}{m}} \cdot \sqrt{\frac{\text{km}^3}{\text{km}^3/\text{sec}^2}} \times \frac{dv}{dt}\left(\frac{\text{km}}{\text{sec}^2}\right) \times 86400 \cdot \left(\frac{\text{sec}}{\text{day}}\right) \times 10^5 \left(\frac{cm}{km}\right)$$

- **Drag estimate using Jacchia-Roberts**

$$\left[\frac{da}{dt}\right]_{\text{Total}} = \left[\frac{da}{dt}\right]_{\text{Anomalous Force}} + \left[\frac{da}{dt}\right]_{\text{Drag}}$$

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FDF Data Conversion

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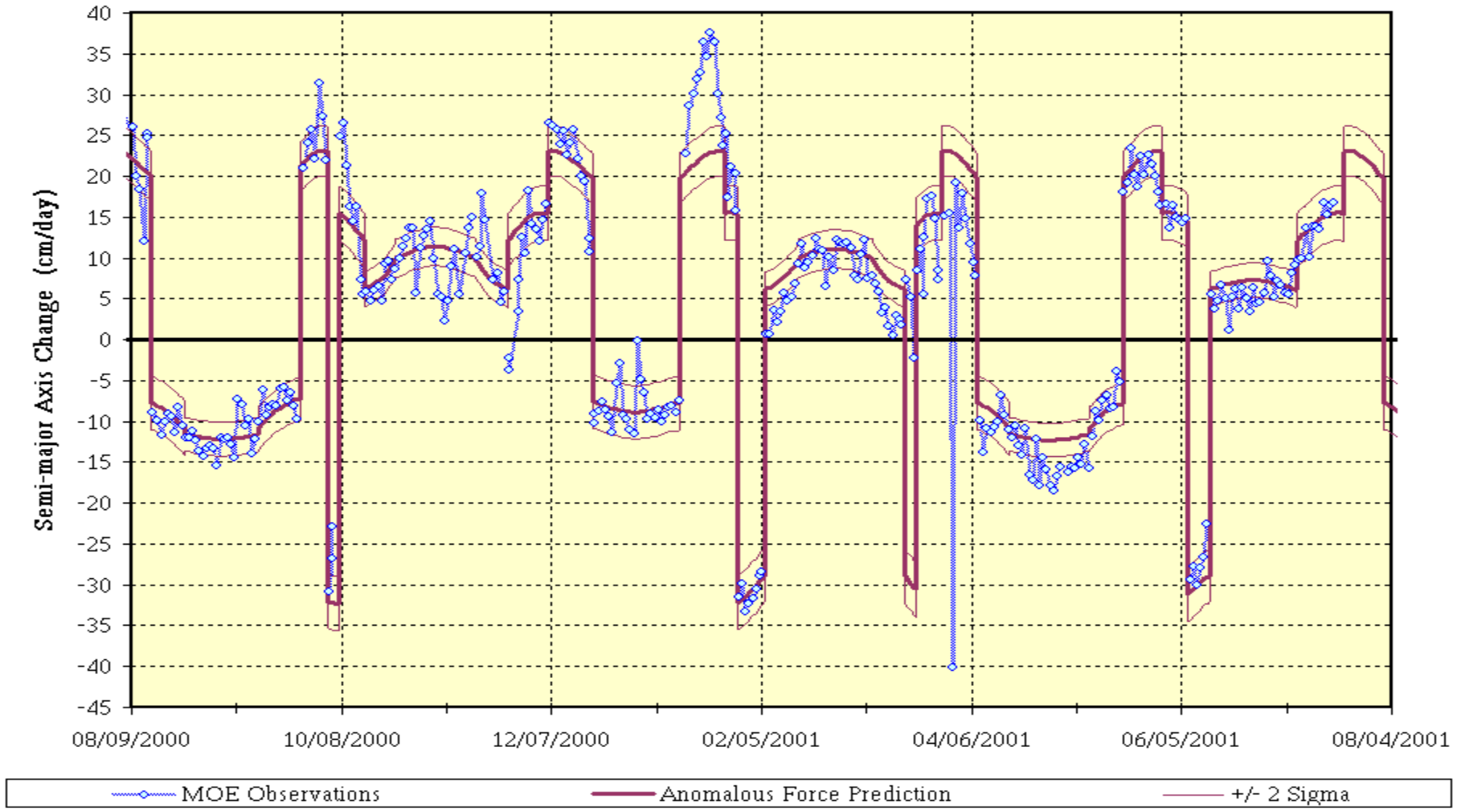
- **Anomalous Force is estimated by a parameter t, in terms of an effective along-track thrust in mNewtons**

$$m\left(\frac{dv}{dt}\right) = [1 + t\,](m \cdot \mathrm{N})$$

- **Conversion to a semi-major axis change in cm/day**

$$\frac{da}{dt}\left(\frac{\mathrm{cm}}{\mathrm{day}}\right) = \frac{2(1+t)}{m}\left(\frac{m \cdot \mathrm{N}}{\mathrm{kg}}\right)\sqrt{\frac{a^3\left(\mathrm{km}^3\right)}{\mathrm{GM}\left(\mathrm{km}^3/\mathrm{sec}^2\right)}} \times 8.64$$

MOE Observations



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FDF Observations

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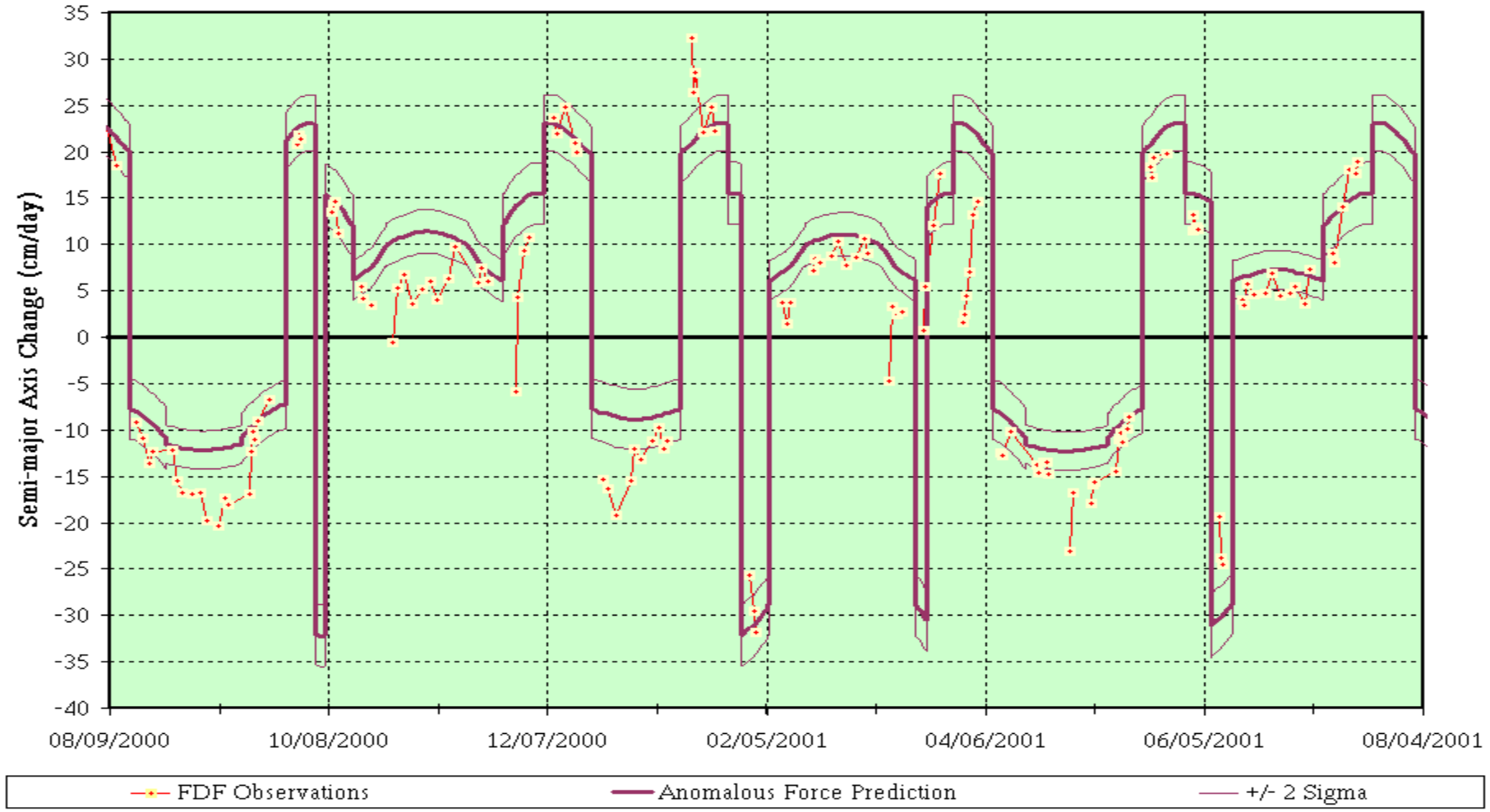
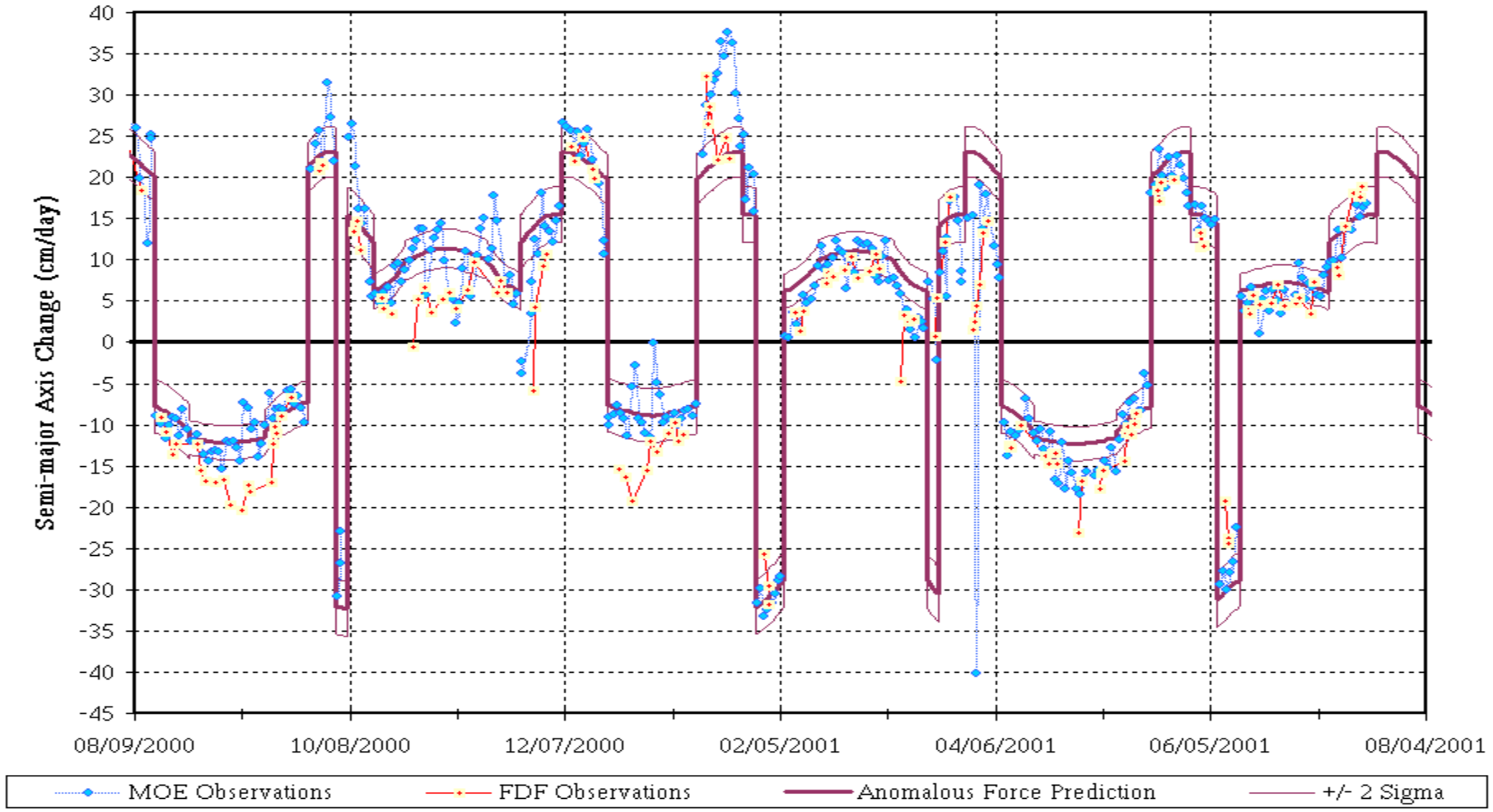


MOE and FDF Observations



Anomalous Force Characteristics

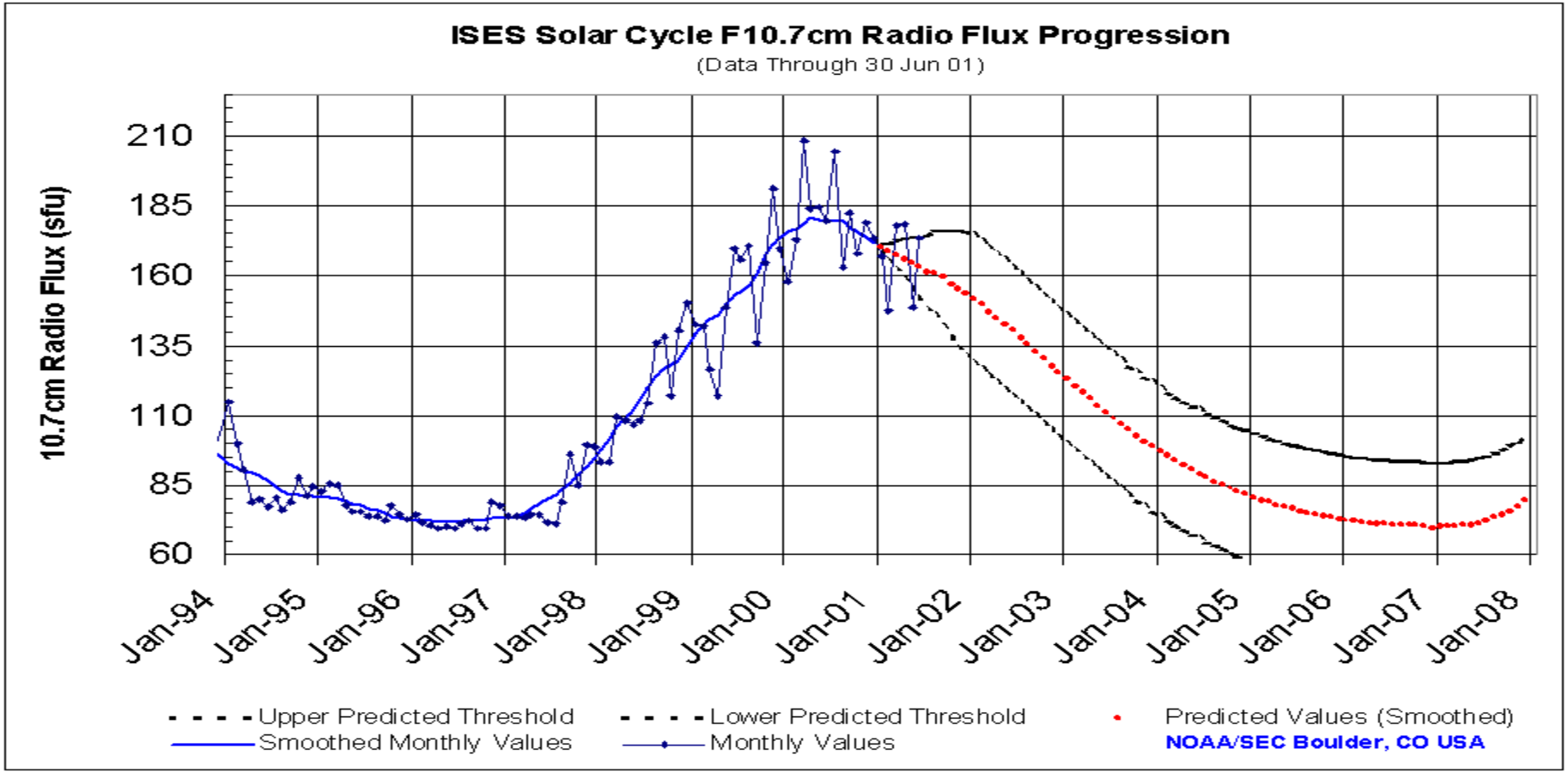
- **Fixed Yaw:**

	Solar Array Pitch Bias 40.0°	Solar Array Pitch Bias - 40.0°
$0^0 \le b \le 30^0$	Variable Boost 15 – 27 cm/day	Variable Decay (No Experience)
$-30^0 \le b \le 0^0$	Variable Decay 30 – 40 cm/day	Variable Boost 7 – 17 cm/day

- **Yaw Steering:**

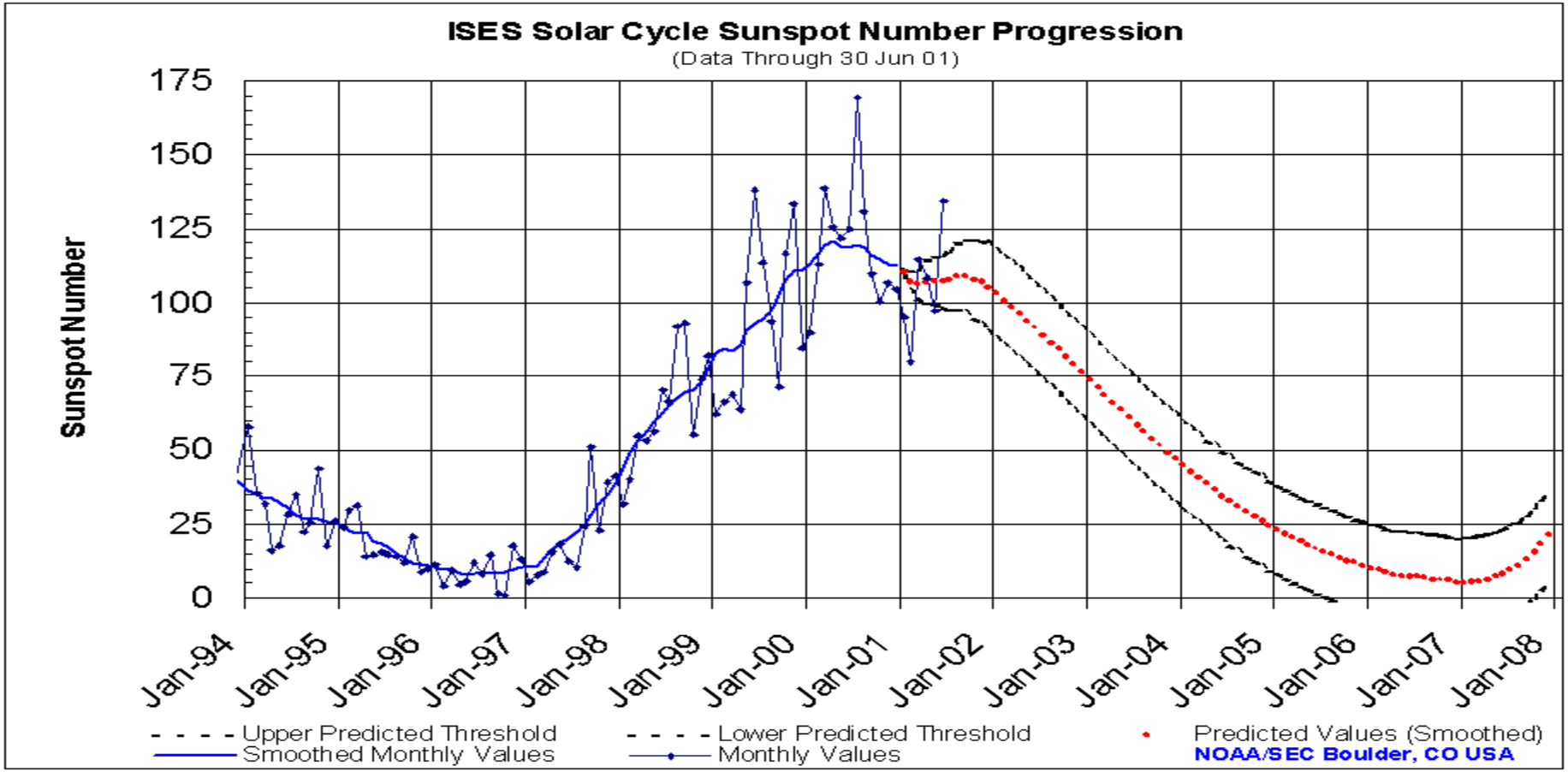
$b > 30^0$	Variable Decay 5 – 15 cm/day
$b < -30^0$	Variable Boost 3 – 13 cm/day

SEC Solar Flux Predictions



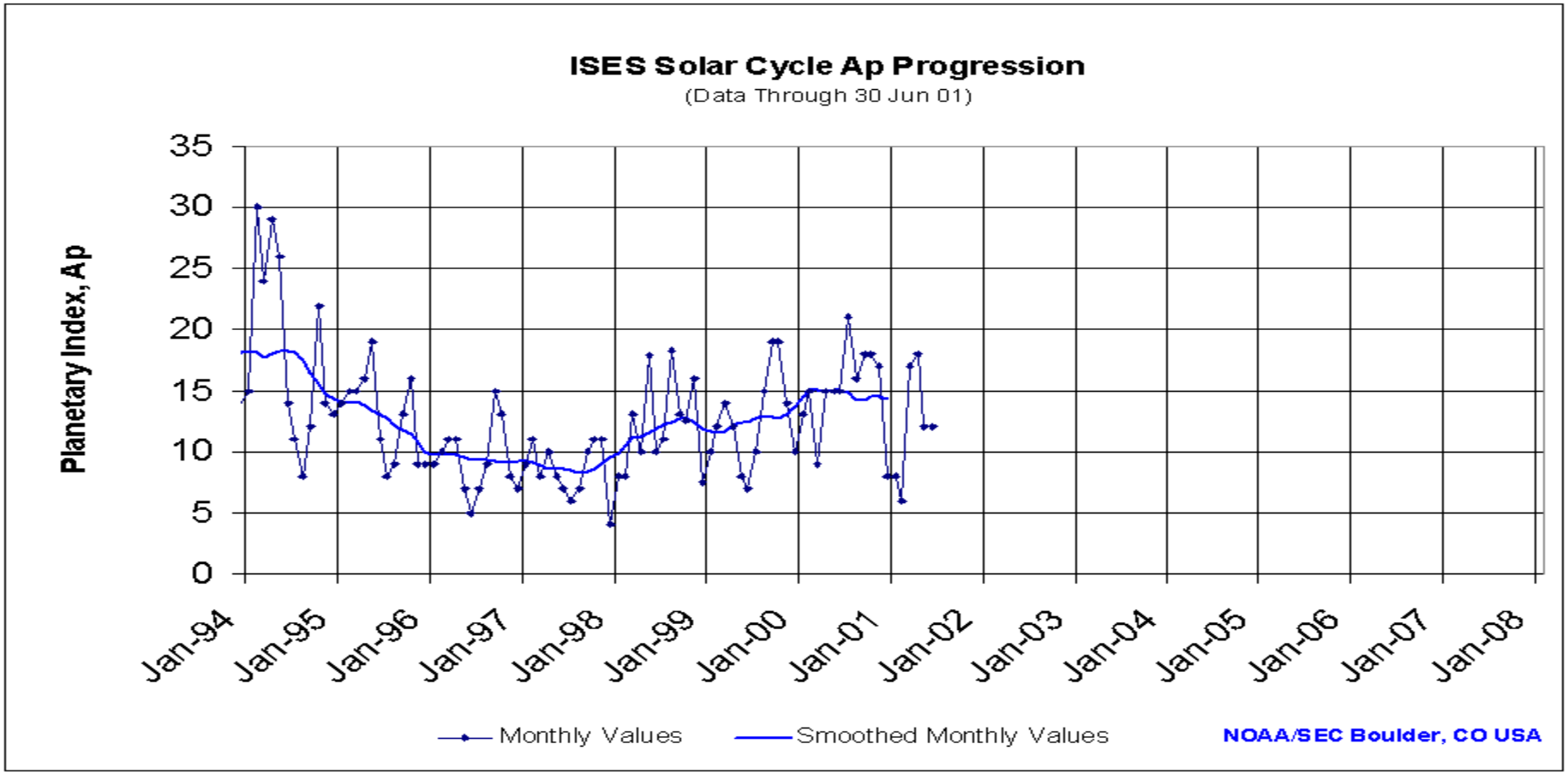
http://sec.noaa.gov/SolarCycle

SEC Sunspot Number Predictions



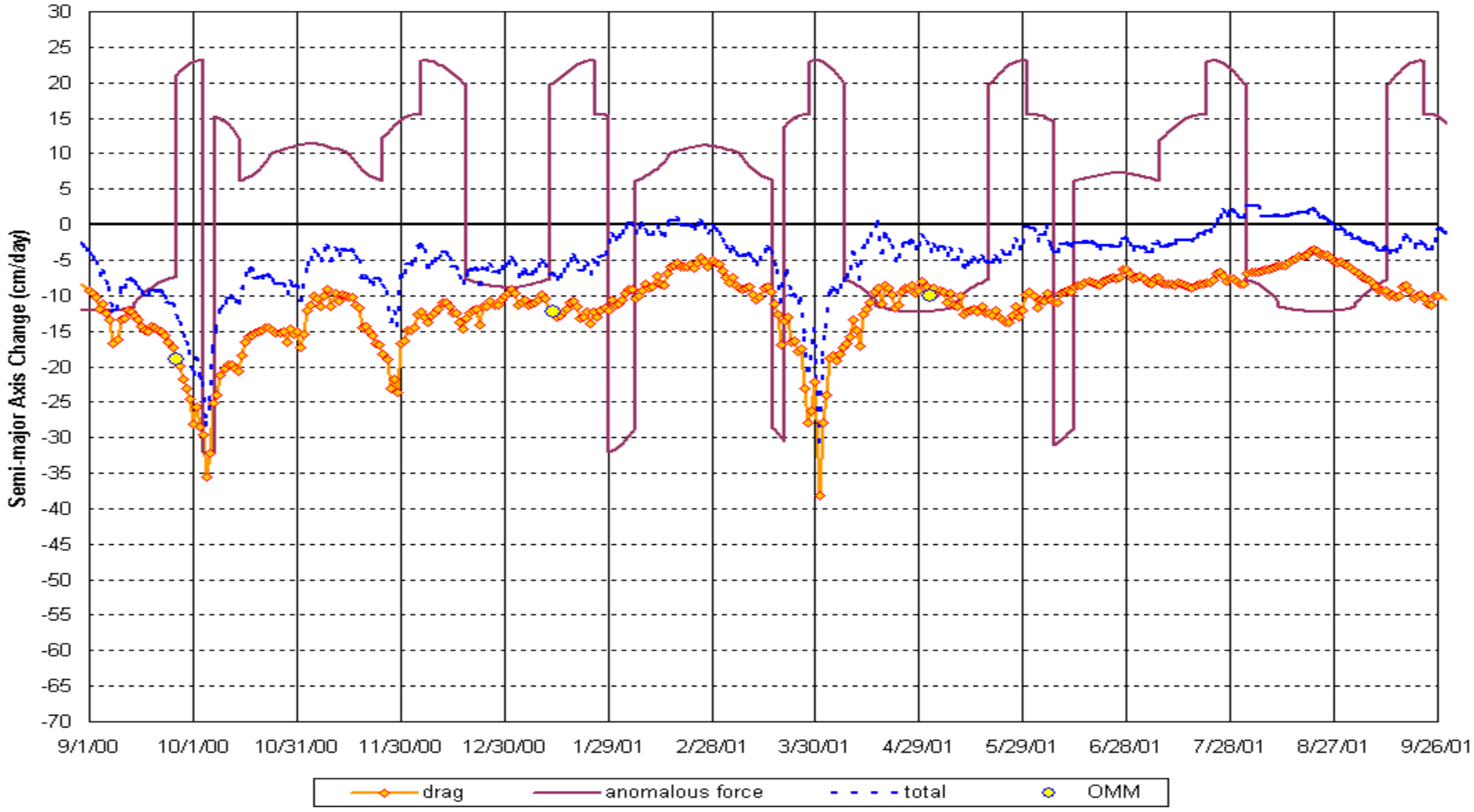
http://sec.noaa.gov/SolarCycle

SEC Geomagnetic Predictions

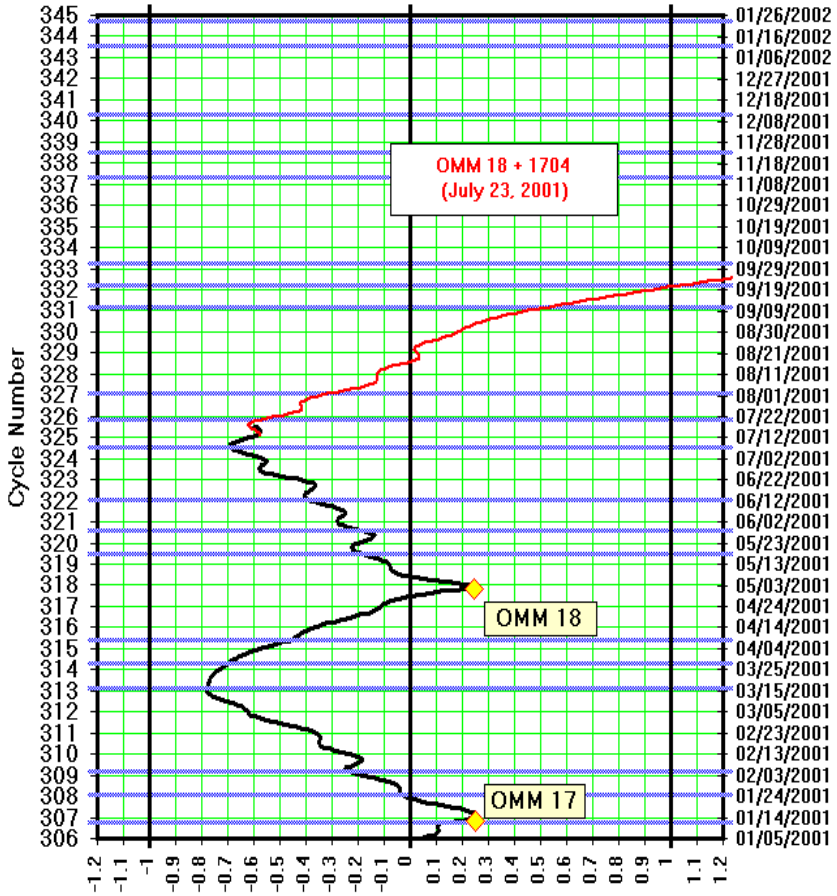


http://sec.noaa.gov/SolarCycle

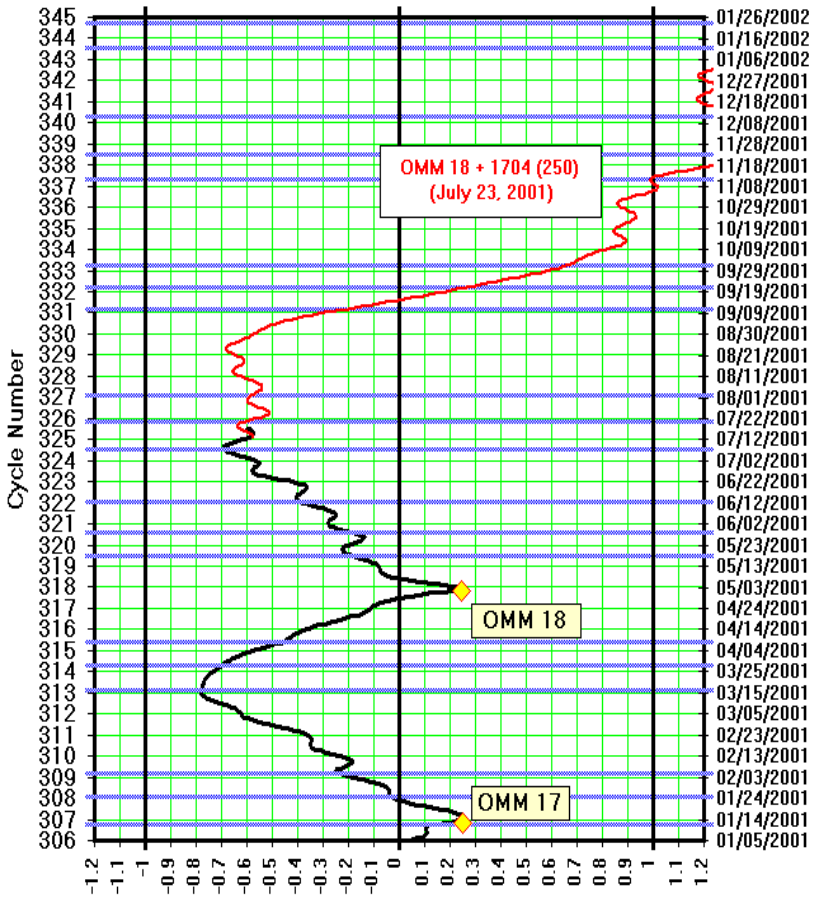
Anomalous Force and Drag



Anomalous Force and Ground Track



Without Anomalous Force



Using Anomalous Force

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Anomalous Force Summary

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MOE and FDF Observations (since August 10, 2000)

- **332 MOE non-gravitational accelerations**
- **143 FDF t estimates**
- **< 5.0 cm/day RMS prediction error**
- **Anomalous Force comparable in magnitude to Drag**
- **No discernible changes in behavior**

Solar Array Pitch Bias (since August 10, 2000)

- **Bias of 40.0^{o} or –40.0^{o} during Fixed Yaw Periods**
- **No recalibration of Models due to solar array pitch bias change**