

Results from the Reanalysis of Global GPS Data in the IGS08 Reference Frame

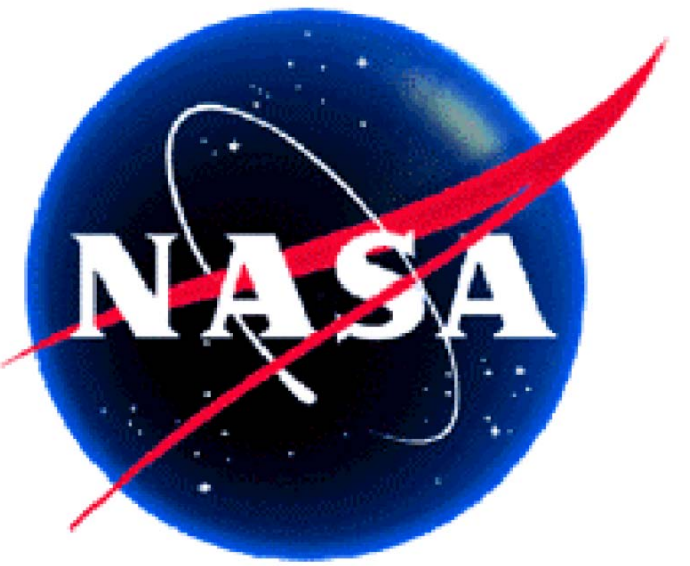
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Abstract

We present results from a reanalysis of global GPS data from 1996-present for the determination of orbit and clock solutions for the GPS constellation using the recently released IGS08 reference frame and IERS2010 standards. The precision of these orbit and clock solutions improves by approximately 20-25% when compared to our previous IGS05-based solutions, primarily due to the use of IGS08-based antenna calibrations and improved models of the solar radiation pressure forces acting on the satellites. We show that when using these IGS08-based orbit and clock products the repeatability of precise point positioning solutions of terrestrial stations improves by 5-30%, particularly in the east component. The products from our reanalysis include information that enables single receiver ambiguity resolved positioning for the entire duration (1996-present). We show that average vertical and transverse station repeatability of 4 and 2 mm, respectively, is achieved when using this capability with the IGS08-based orbit and clock solutions for the GPS constellation. This represents an additional improvement of 5-10% in the vertical and north components, and more than 40% in the east component.

Status of IGS08 Reprocessed GPS Orbit/Clock Products

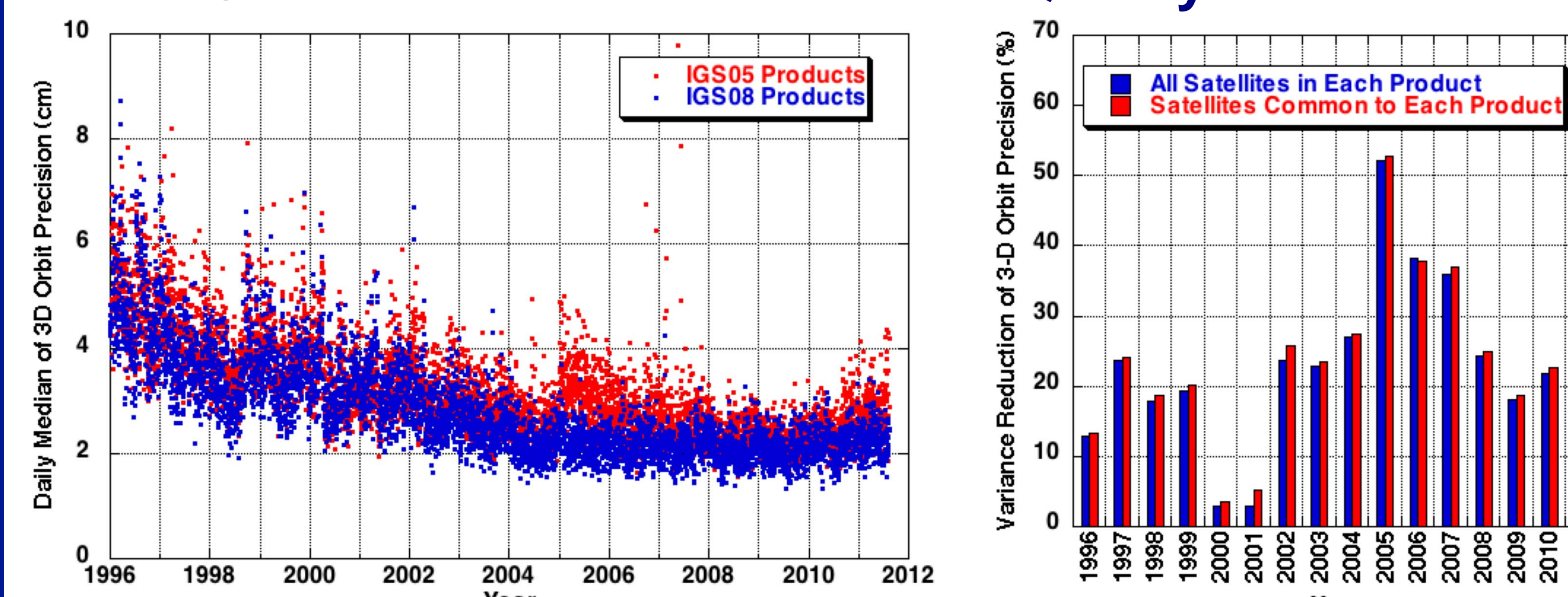
• JPL's reprocessed GPS satellite orbit and clock products enable single receiver phase ambiguity resolution with GIPSY/OASIS software spanning 1996-present.

- 1996-present global GPS data reprocessed in IGS08 reference frame and released October 2012.
- Number of GPS satellites in product increased by average of 0.6 satellites/day.
- Terrestrial precise point positioning with these products evaluated with three approaches:
 - ① IGS05: Products from 2009 reprocessing campaign, IGS05 reference frame, without single receiver phase ambiguity resolution (not available 1996-2009).
 - ② IGS08 (Not Resolved): Products from 2011 reprocessing campaign, IGS08 reference frame, without single receiver phase ambiguity resolution.
 - ③ IGS08 (Resolved): Same as (2), using single receiver phase ambiguity resolution.

IGS08 Reprocessing Strategy

Orbit Arc	30 hours
Number of Stations	80
Elevation Angle Cutoff	7 degrees
Station Information	IGS08 Sinex and Discontinuity
Receiver/Transmitter Antenna Calibrations	igs08.atx
Troposphere Mapping Function	GMF
A Priori Dry Troposphere Model	GPT
Solid Earth Tide (dynamic and geometric)	IERS2010
Pole Tide (dynamic and geometric)	IERS2010
Ocean Tide Loading Model	FES2004 with harddisp.f
Earth Orientation	IERS 2010 Tidal Model EOPC04 (ITRF08 +IAU2000)
Static Gravity Field	EGM2008 (12x12)
Ocean Tide Gravity Field	FES2004 (convolution)
Solar Radiation Pressure	GSPM10 (JPL)
Albedo Model	Applied

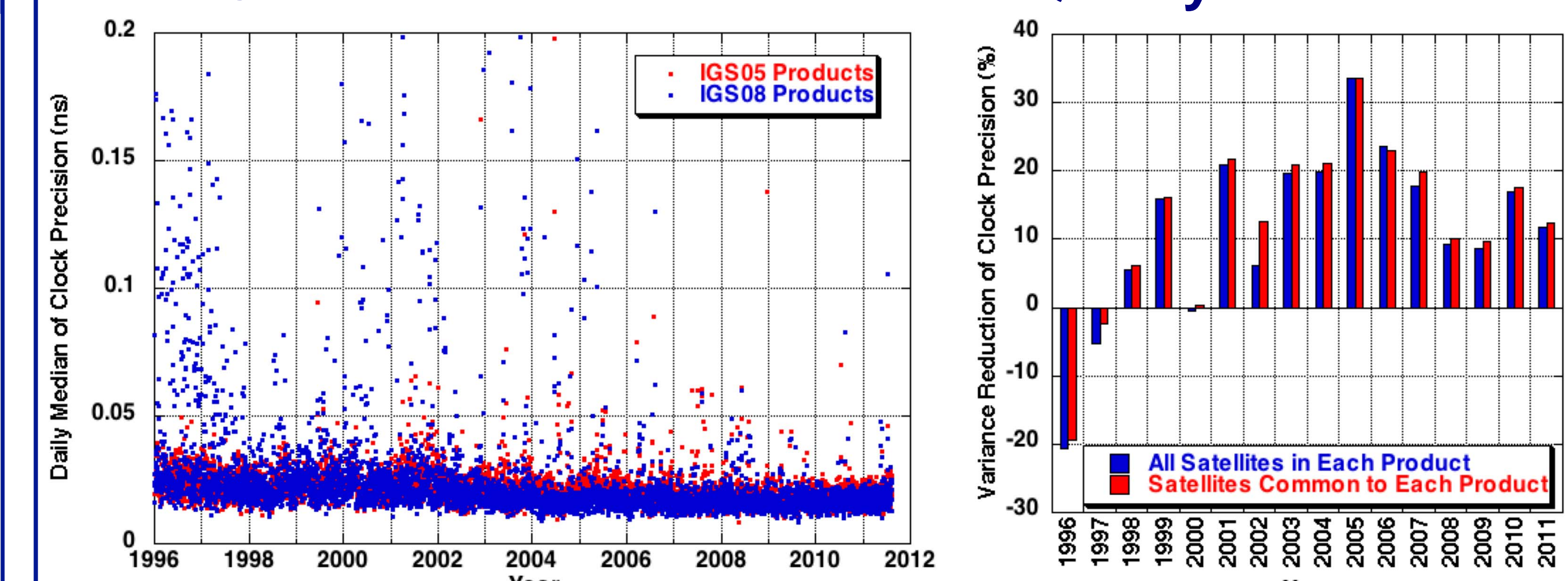
Orbit Precision from Internal Quality Metrics



25% average variance reduction in orbit precision (3.1 to 2.7 cm 3D).

- Orbit precision measured as RMS of 3-D orbit overlap differences for each GPS satellite using middle 5 hours of 6-hour daily overlap.
 - Median RMS of 3-D orbit differences from all satellites in each day shown above.
 - Overlap differences provide measure of self-consistency and precision.
- Slight discontinuity in IGS05 solutions for 2005-2006 eliminated in IGS08 solutions.
- IGS05 and IGS08 solutions both have discontinuity in orbit precision time series for 1999-2000.
 - Will be reprocessed again in early 2012 to improve solutions.

Clock Precision from Internal Quality Metrics



12% average variance reduction in clock precision (0.021 to 0.020 ns).

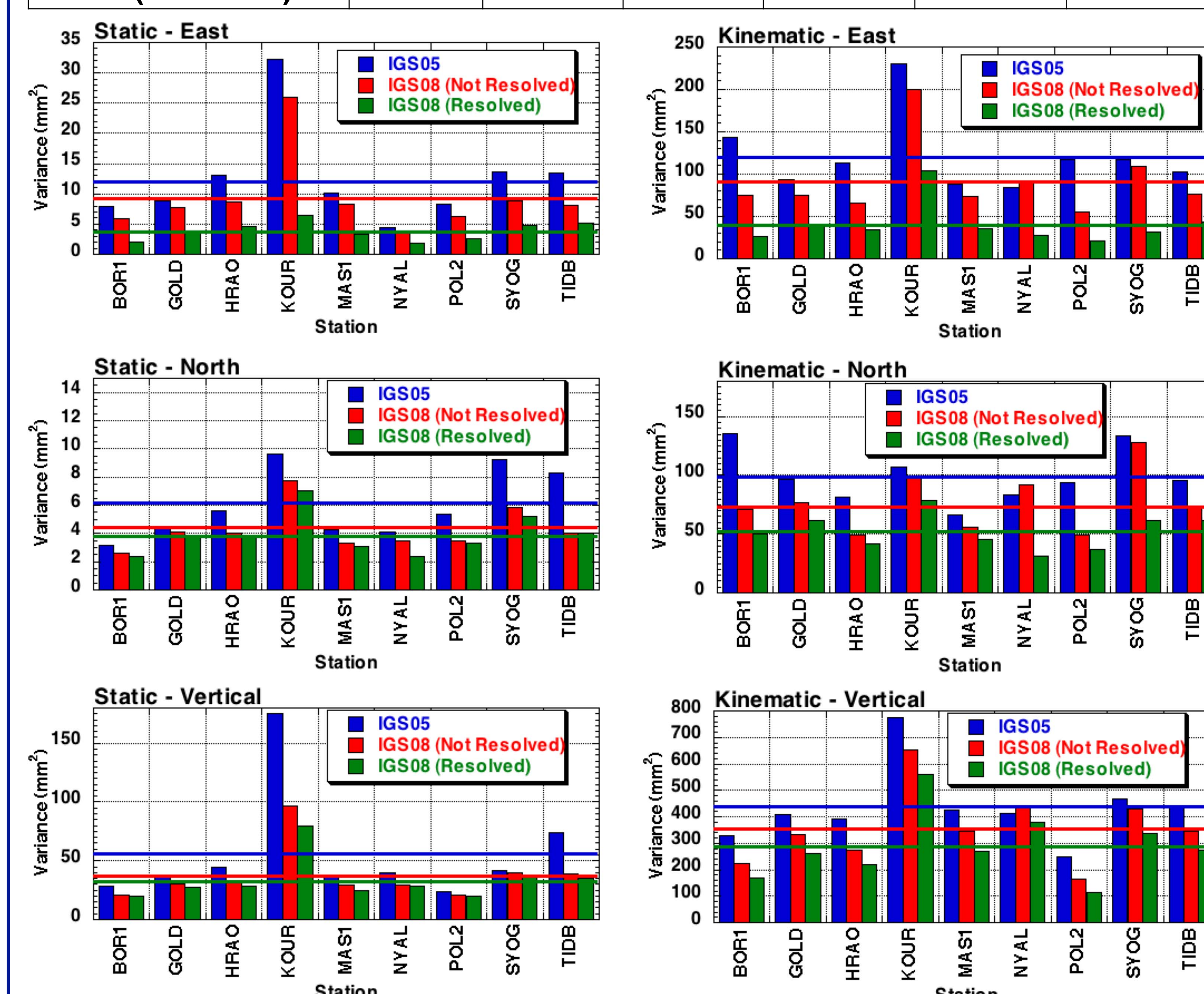
- Clock precision measured as RMS of clock overlap differences for each GPS satellite for middle 5 hours of 6-hour daily overlap.
 - Median RMS of clock difference from all satellites in each day shown above.
 - Overlap differences provide measure of self-consistency and precision.
- Degraded day-to-day clock consistency observed in 1996 and 1997.
 - IGS05 and IGS08 clock solutions for 1996 have 41 and 97 days with clock overlaps > 0.05 ns, respectively.
 - Likely to be related to reference clock selection in IGS08 versus IGS05 solutions.

Station Repeatability with New Orbit/Clock Products

30-70% average variance reduction station repeatability from improved accuracy of orbit and clock products, AND using single receiver ambiguity resolution.

- 9 stations selected for global coverage and > 12-year occupation history.
- Static Point Position = Estimate 1 station position every day.
- Kinematic Point Position = Estimate 1 station position every 5 minutes.

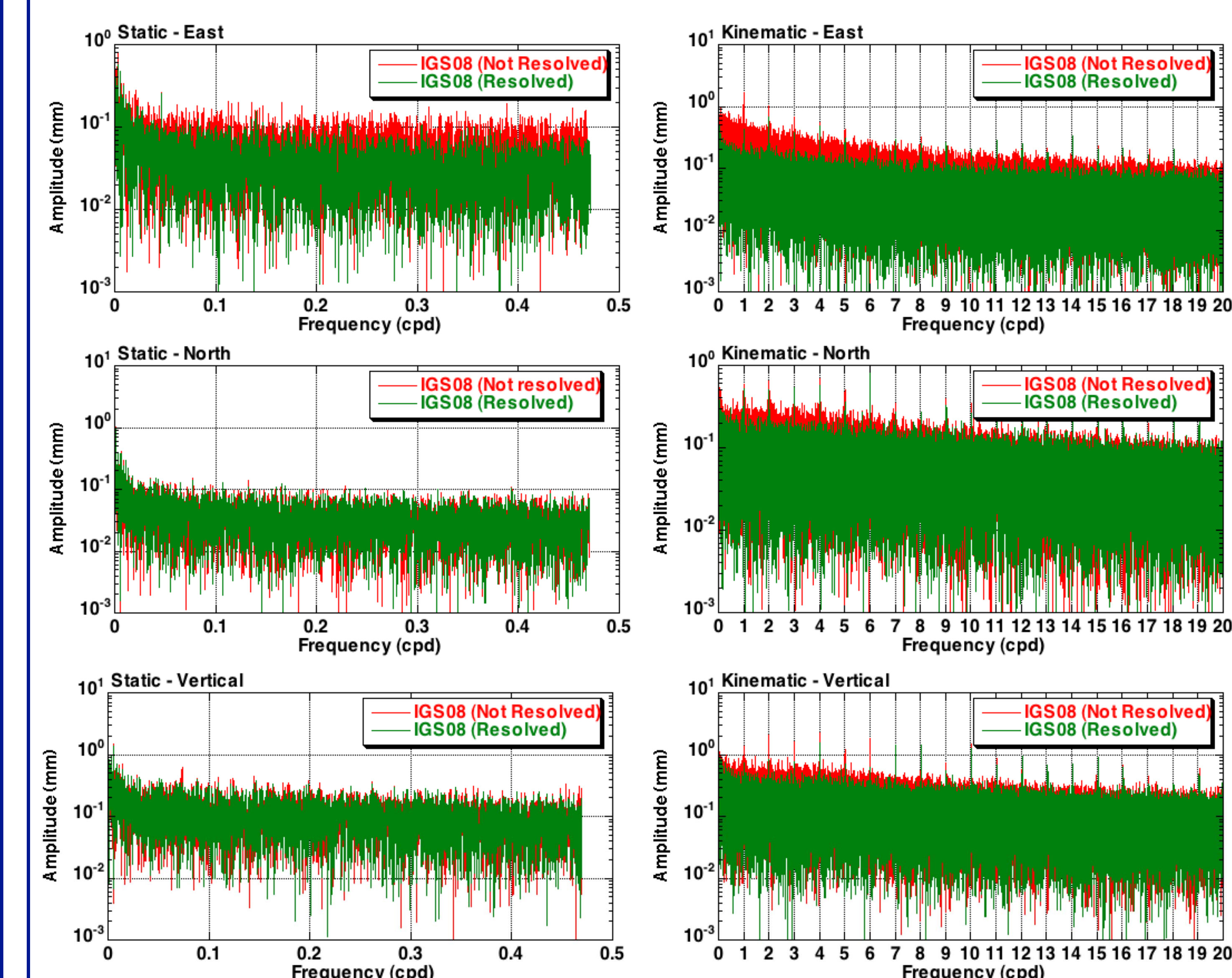
	Static Point Positions (mm)			Kinematic Point Positions (mm)		
	East	North	Up	East	North	Up
IGS05	3.5	2.4	7.5	11.0	10.0	20.8
IGS08 (Not Resolved)	3.0	2.1	6.1	9.5	8.8	18.9
IGS08 (Resolved)	2.0	2.0	5.8	6.3	7.2	16.9



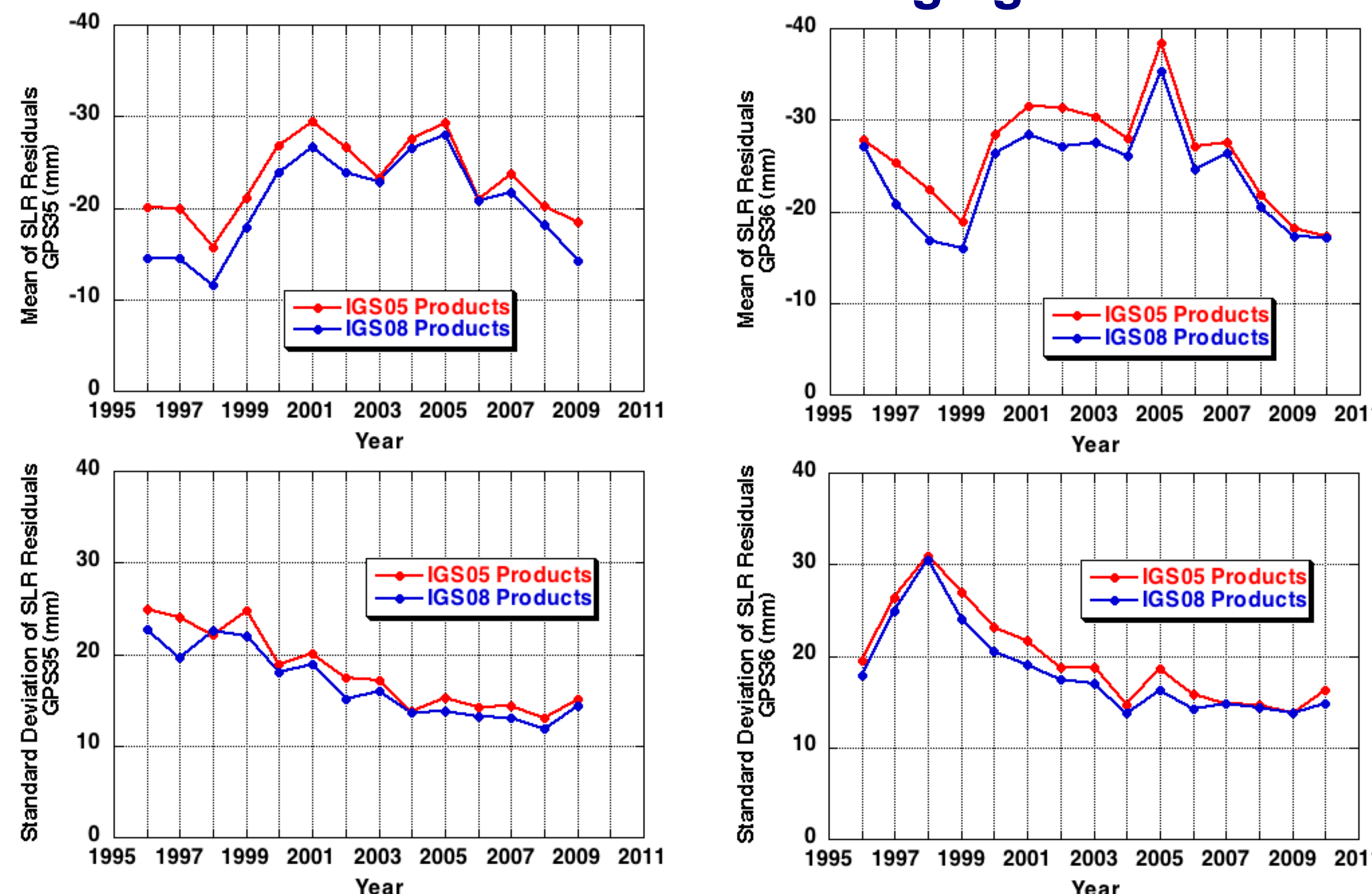
Impact of Single Receiver Phase Ambiguity Resolution on Station Position Spectral Decomposition

Reduced power primarily at frequencies < 6 cycles/day (periods > 4 hours)

- East component of terrestrial positions has most significant percentage variance reduction at all frequencies.
 - Observed in both static and kinematic point positions.
 - Likely due to north/south geometry of GPS satellite orbits.
- East and north components have similar repeatability after ambiguity resolution.
- Kinematic point positions have spikes at integer multiples of 1 cycle/day.
- Due to independent solutions each day, and exaggerated by unconstrained white noise estimation strategy.



External Measure of Orbit Accuracy Satellite Laser Ranging



14% average variance reduction in satellite laser ranging (SLR) residuals.

2-3 mm reduction in SLR bias.

	Bias (mm)		Std. Dev. (mm)	
	GPS35	GPS36	GPS35	GPS36
IGS05	-23	-26	18.2	19.7
IGS08	-20	-24	16.8	18.2