Russian Academy of Sciences
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Celestial pole offset: from initial analysis to end user

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Motivation

Celestial Pole Offsets (CPO) are the small differences between actual and modeled CIP positions. The main CPO applications are the following:

1. CPO is needed for highly accurate TRF<–>CRF transformation. IERS CPO series is recommended for practical use. Which one? OPA or NEOS?

2. CPO series are used for adjusting of precession-nutation model. Result depends on the series used.

3. CPO series are used for evaluation of Free Core Nutation (FCN) model. Result depends on the series used.

CPO technology chain

CPO time series are initially computed at the IVS Analysis Centers (ACs). Each AC computes series containing results obtained for each processed 24-hour VLBI session in two modes: 'eops' ('eoxy') files with final EOP values and/or datum free normal equations (daily SINEX).

The daily SINEX solutions are then used at the IVS Combination Center (CC) to derive the IVS combined CPO series, also given for each VLBI session.

IERS CCs at OPA and USNO use original ACs' and IVS combined series to derive the IERS daily combined products at midnight epochs. OPA and USNO use different methods and data sets.

Available options for users

The following CPO series are available:

1. IERS/C04 series (official, not for near-real-time applications.

2. IERS/NEOS series (official for near-real-time application and prediction).

3. IVS combined series computed at the IVS CC (officially, only 'sub-product' for IERS combination).

4. Individual series computed at IVS ACs.

All these series are used in practice.
How consistent they are?

Comparisons of interest

1. Individual 'eops' series computed at IVS ACs **vs.** individual series computed at the IVS CC from daily SINEX solutions.

2. Individual series **vs.** IVS combined series.

3. IVS combined series **vs.** C04 and NEOS IERS series.

4. C04 **vs.** NEOS series.

CPO series used

Number of CPO epochs (MJD 53374.2-55971.2)

AC	Computed at AC and submitted as 'eops'	Computed at the IVS CC from daily SINEX*
BKG	1034	713, 713
DGFI	–	556, 468
GSFC	1101	708, 686
IAA **	892	259, 57
OPA***	1179	359, 351
USNO	979	578, 237
IVS****	727	727
C04**** (daily)	2598	–
NEOS**** (daily)	2598	–

* - total # of CPO epochs and # of epochs with non-zero values

** - different software used for .eops and SINEX submissions

*** - late start of SINEX series

**** - different input data and methods are used for combination

Comparison of 'eoxy' and SINEX series, smoothness

2D weighted Allan variance, µas

(not corrected for different number of epochs yet)

AC	Computed at AC and submitted as 'eops'	Computed at the IVS CC from daily SINEX
BKG	154	167
GSFC	131	137
OPA	136	139
USNO	130	141

Smoothness of combined series

2D weighted Allan variance, μas

Series	ADEV	Note
IVS	128	raw
C04	45	smoothed
NEOS	22	smoothed

Bias, original series

Bias w.r.t. the IAU precession-nutation model, µas
(not corrected for different set of epochs yet, mainly affects last two columns for USNO)

AC	Computed at AC and submitted as 'eops'		Computed at the IVS CC from daily SINEX	
	dX	dY	dX	dY
BKG	75 ± 5	-92 ± 6	113 ± 8	-157 ± 7
GSFC	99 ± 5	-136 ± 3	120 ± 7	-193 ± 7
OPA	93 ± 5	-126 ± 5	132 ± 11	-112 ± 11
USNO	95 ± 5	-128 ± 6	(72 ± 11)	(-201 ± 9)
IVS	–		84 ± 8	-170 ± 7
C04	70 ± 4	-82 ± 4	–	
NEOS	12 ± 3	-39 ± 4	–	

Bias, after removing FCN (IERS/SL model)

Bias w.r.t. the IAU precession-nutation model, μas

(not corrected for different set of epochs yet, mainly affects last two columns for USNO)

AC	Computed at AC and submitted as 'eops'		Computed at the IVS CC from daily SINEX	
	dX	dY	dX	dY
BKG	74 ± 3	-105 ± 3	87 ± 5	-173 ± 4
GSFC	96 ± 3	-142 ± 3	89 ± 4	-199 ± 4
OPA	89 ± 3	-134 ± 3	78 ± 6	-141 ± 6
USNO	90 ± 3	-137 ± 3	(71 ± 6)	(-208 ± 7)
IVS	–		84 ± 4	-190 ± 4
C04	74 ± 2	-96 ± 2	–	
NEOS	15 ± 1	-119 ± 2		

Linear trend, original series

Slope w.r.t. the IAU precession-nutation model, µas/yr
(not corrected for different set of epochs yet, mainly affects last two columns for USNO)

AC	Computed at AC and submitted as 'eops'		Computed at the IVS CC from daily SINEX	
	dX	dY	dX	dY
BKG	-1.5 ± 2.8	29.7 ± 3.0	2.1 ± 3.8	24.1 ± 3.2
GSFC	-6.1 ± 2.5	23.4 ± 2.7	5.1 ± 3.3	28.2 ± 3.4
OPA	-3.5 ± 2.5	20.0 ± 2.6	17.6 ± 10.2	41.3 ± 7.8
USNO	0.7 ± 2.7	21.0 ± 2.9	(-26.3 ± 8.4)	(44.3 ± 8.1)
IVS	–		-16.4 ± 3.3	28.2 ± 3.2
C04	-15.1 ± 1.8	59.7 ± 1.8	–	
NEOS	-1.1 ± 1.6	50.9 ± 1.7	–	

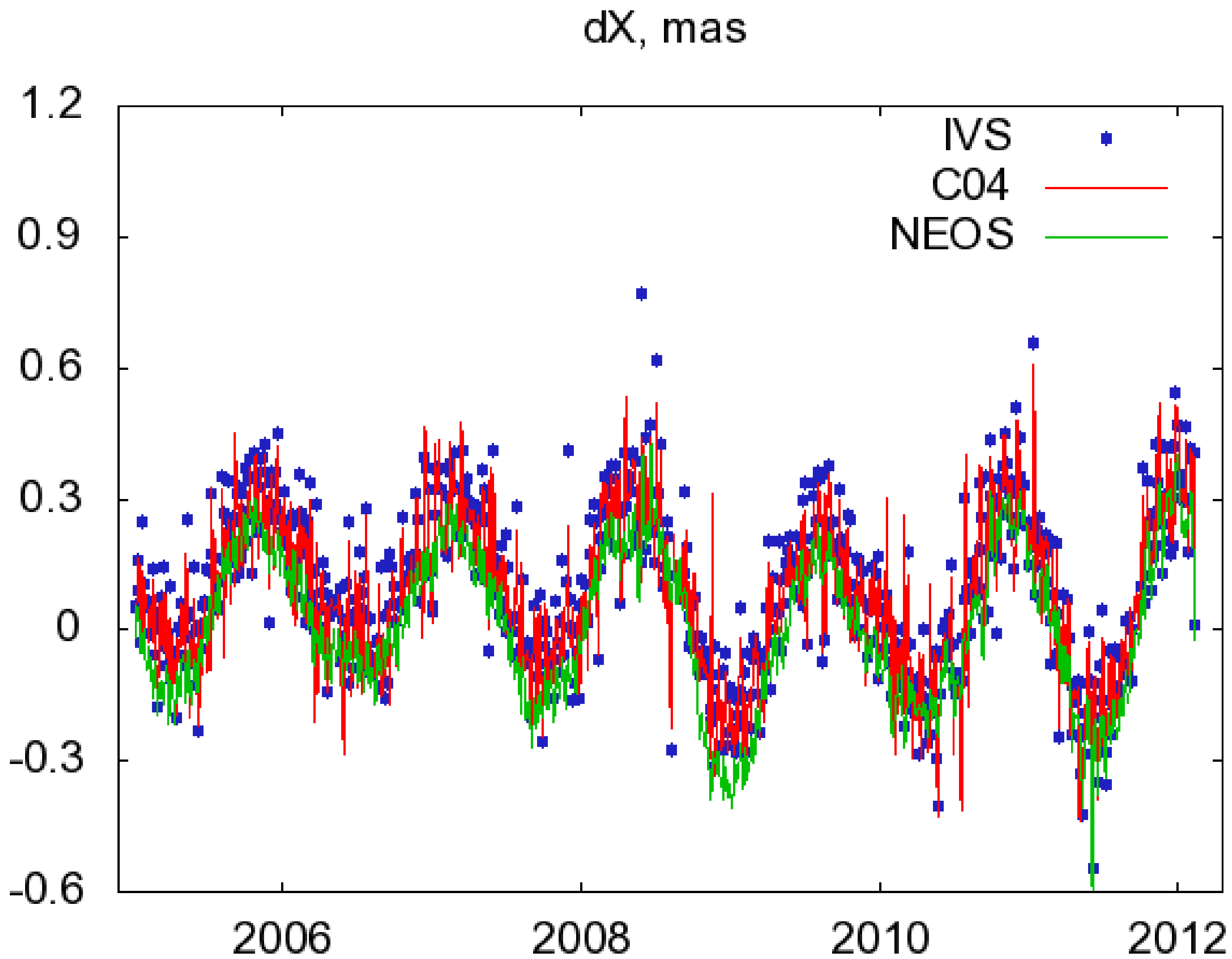
Linear trend, after removing FCN (IERS/SL model)

Slope w.r.t. the IAU precession-nutation model, µas/yr

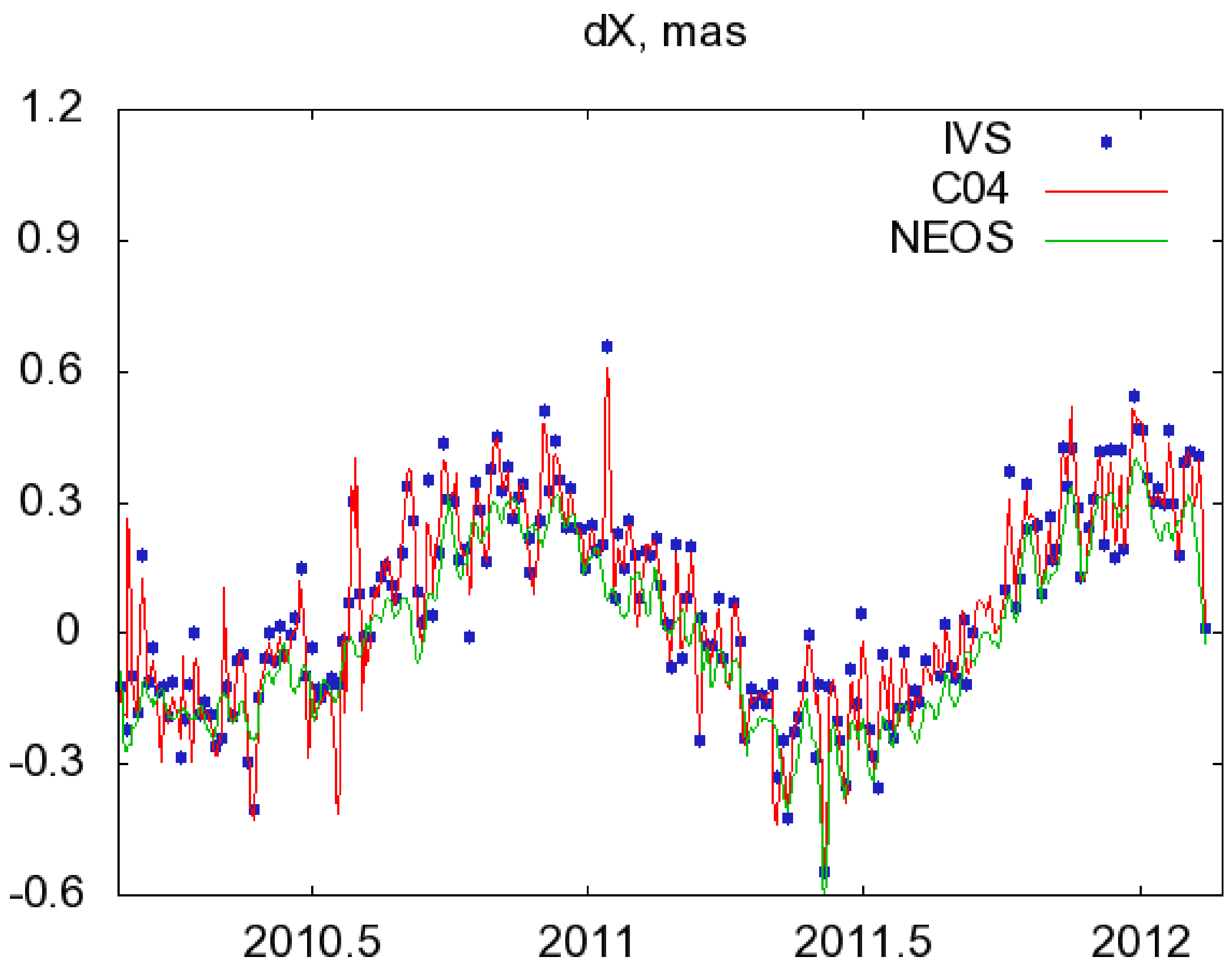
(not corrected for different set of epochs yet,
mainly affects last two columns for USNO)

AC	Computed at AC and submitted as 'eops'		Computed at the IVS CC from daily SINEX	
	dX	dY	dX	dY
BKG	-4.3 ± 1.7	19.5 ± 1.6	-7.9 ± 2.1	23.1 ± 2.0
GSFC	-7.8 ± 1.4	18.8 ± 1.4	-5.9 ± 1.7	26.4 ± 1.9
OPA	-5.8 ± 1.4	15.5 ± 1.4	9.8 ± 5.1	33.4 ± 4.3
USNO	-4.6 ± 1.5	16.2 ± 1.5	(-23.6 ± 4.4)	(1.3 ± 6.1)
IVS	–		-14.6 ± 1.8	24.3 ± 1.8
C04	-12.0 ± 1.0	35.6 ± 0.8	–	
NEOS	-7.6 ± 0.7	25.8 ± 0.8	–	

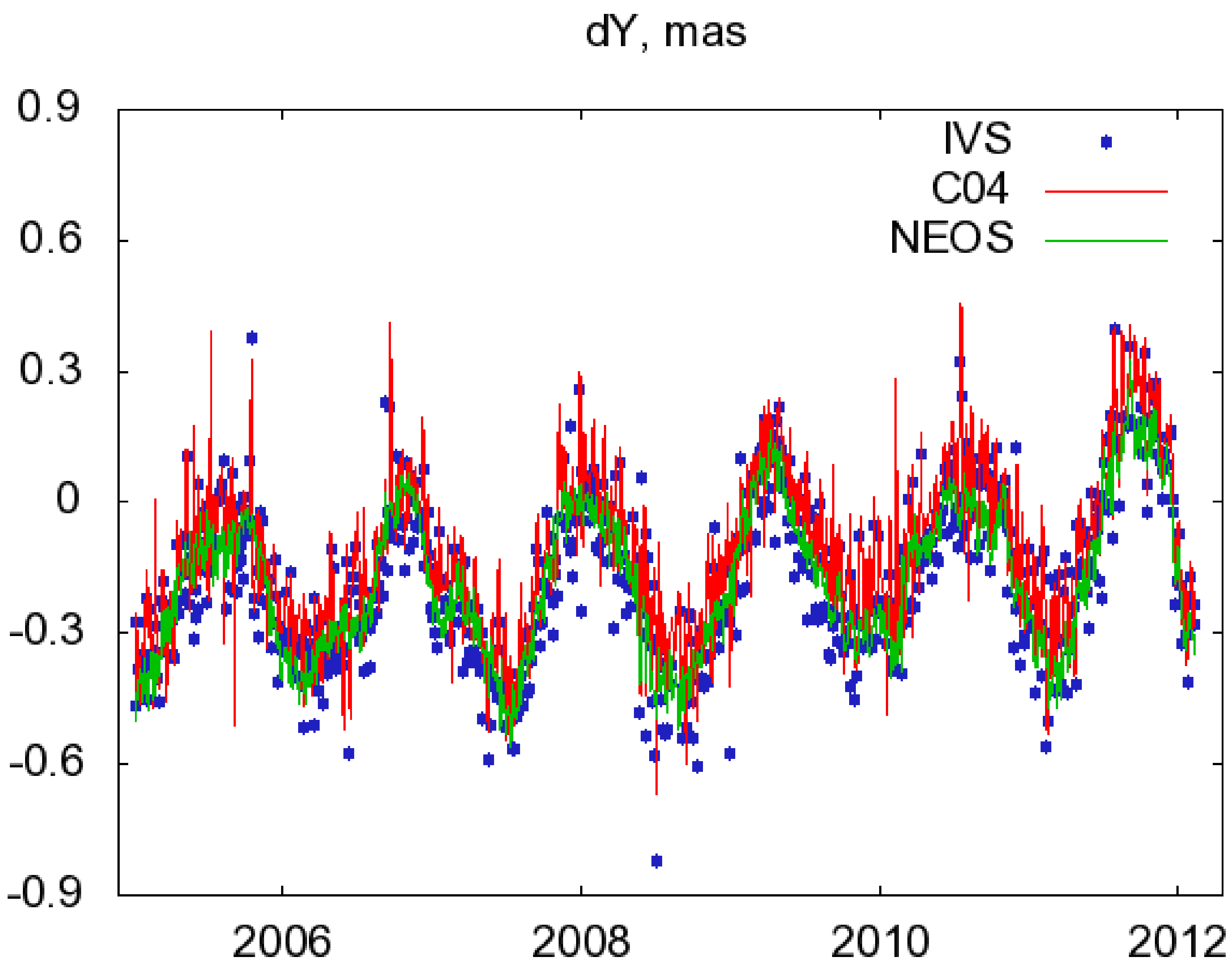
Comparison of combined series, dX



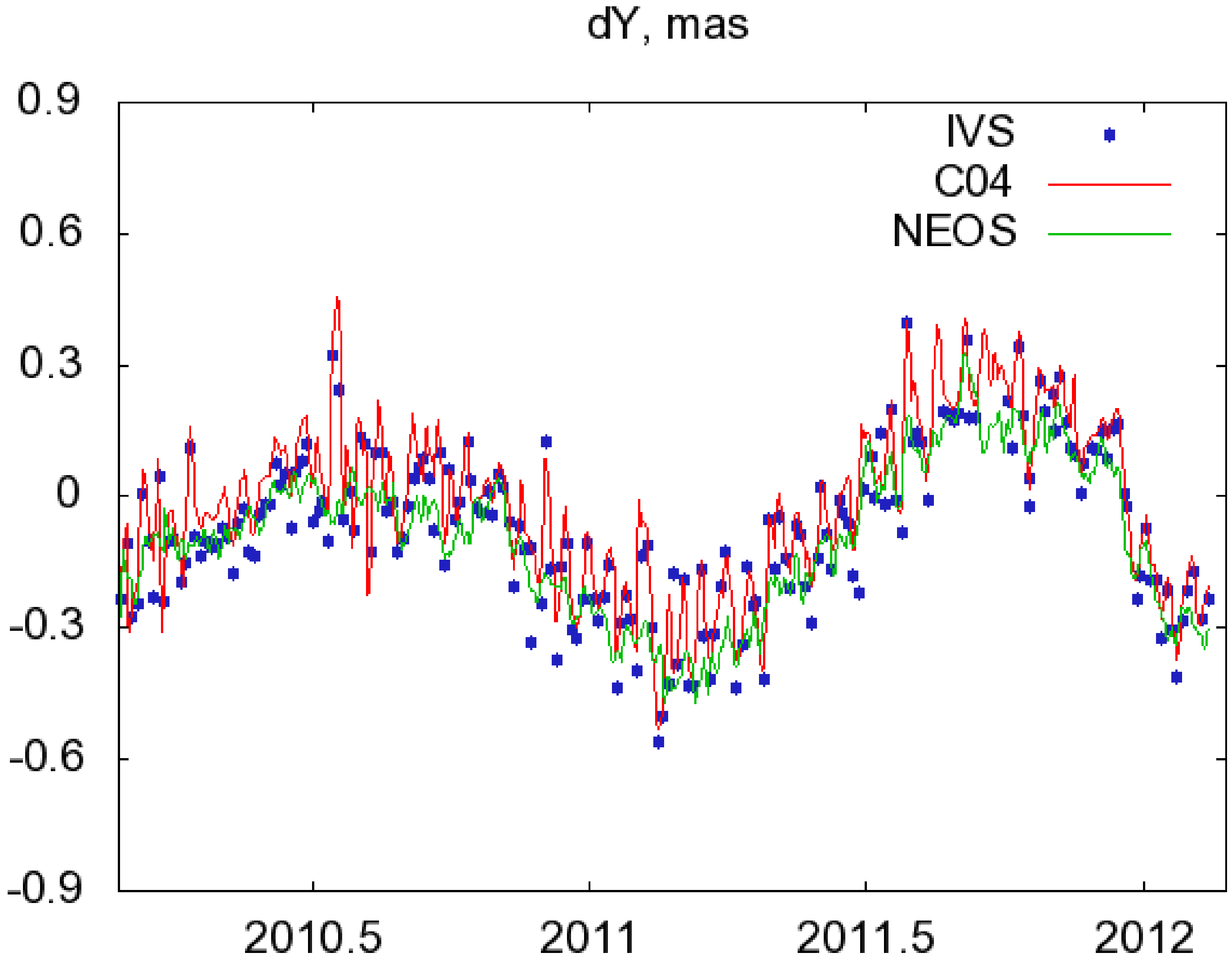
Comparison of combined series, dX



Comparison of combined series, dY



Comparison of combined series, dY



Concluding remarks

Presented results are yet preliminary. However significant random and systematic differences do exist between the IVS ACs' , combined IVS, and two IERS CPO series.

These discrepancies affect space geodesy data processing (e.g. satellite applications, VLBI UT1 intensives), accuracy of precession-nutation and FCN models, etc.

This situation requires more careful investigation and perhaps more coordination between IVS and IERS.

More specific IERS Conventions recommendations on the CPO issues are very desirable for applications required the microarcsecond level of accuracy.

Concluding remarks

The quality of the IERS CPO series depends on the interpolation and smoothing algorithms.

IVS series may be preferable for some applications such as improvement of precession-nutation and FCN models.

Thank you for your attention!