Improvements concerning EOP combinations

Daniel Gambis, Christian Bizouard

Morad Saïl, Teddy Carlucci, Gérard Francou

IERS Orientation Centre, Observatoire de Paris, FRANCE

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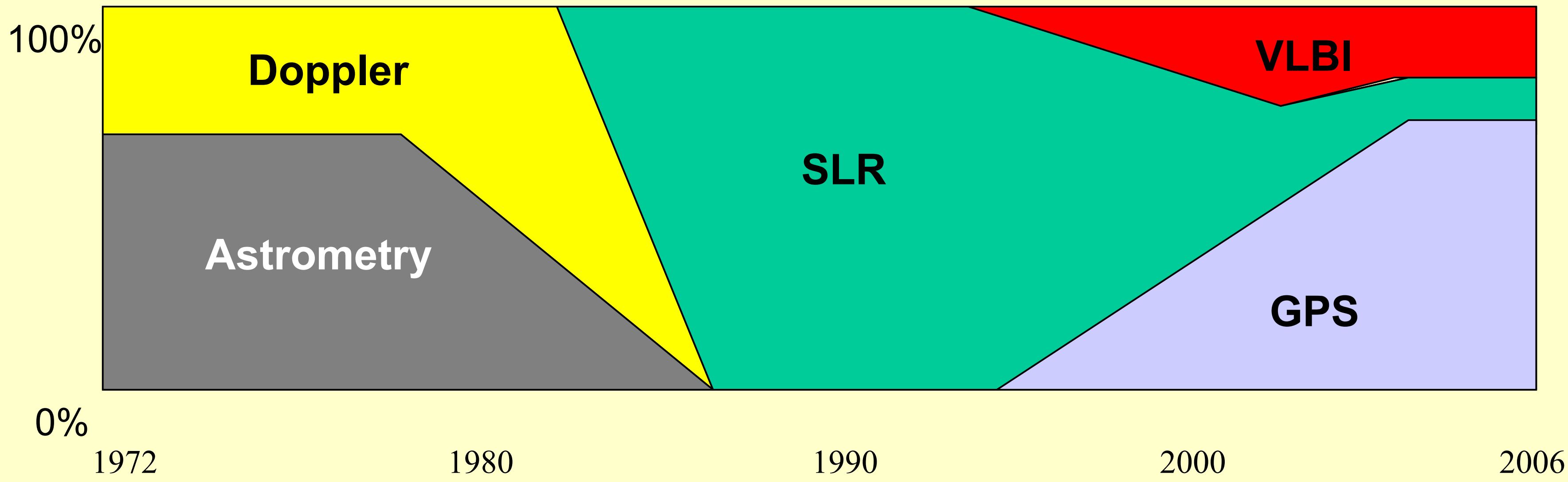
Outline of the presentation

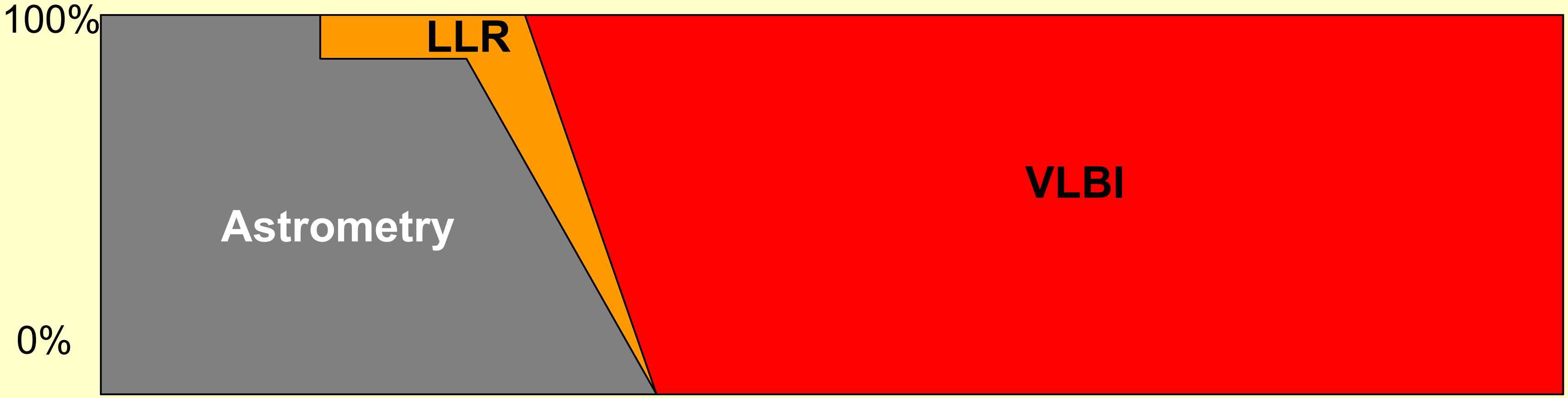
- Evolution of techniques, precision and accuracy
- Maintenance of the EOP system,
- (In)consistency between EOP system and TRF
- Short and long-term noise behaviour of GPS, SLR and VLBI
- Improvements in the C04 computation

Contributions of techniques to combined solutions

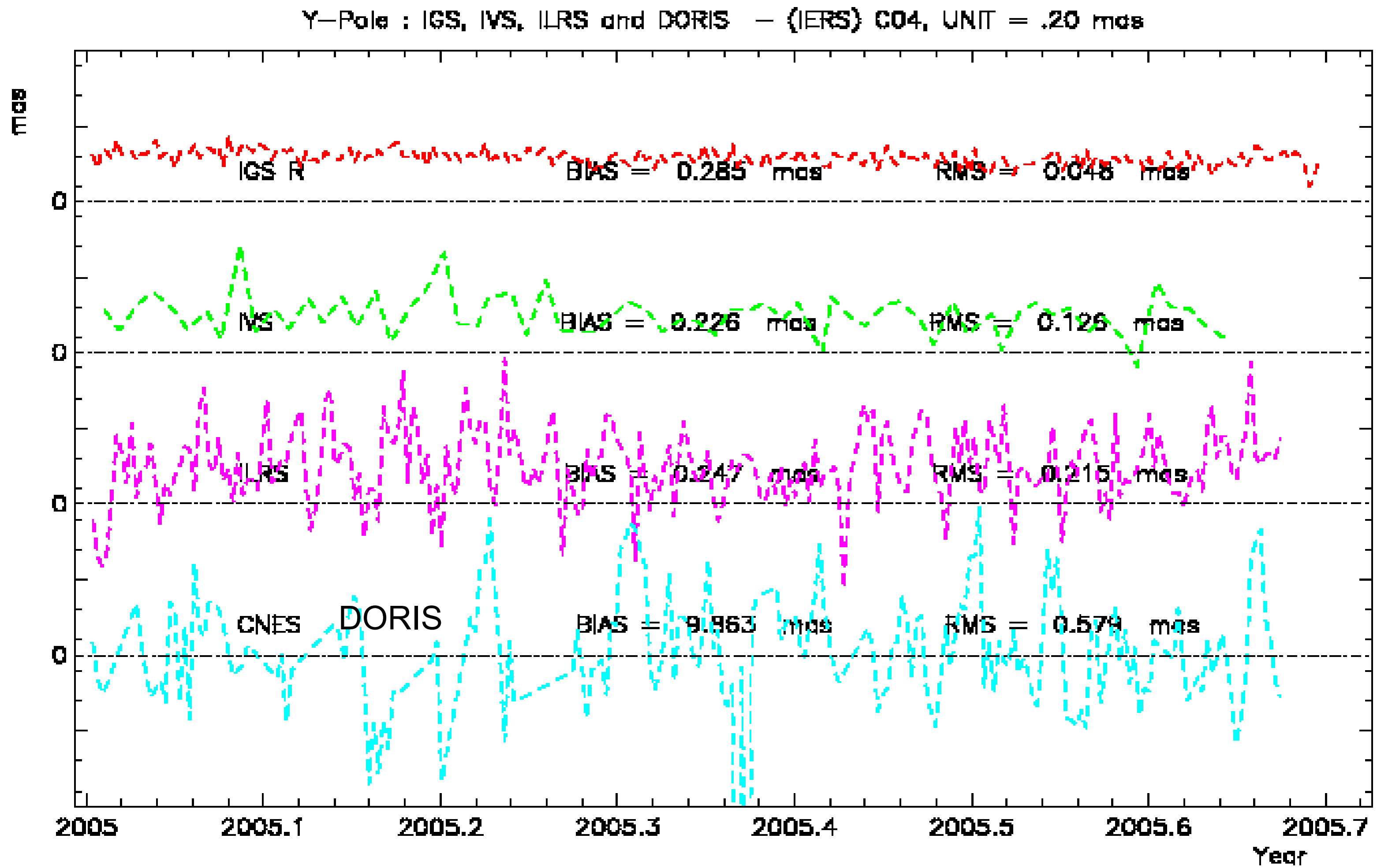
Polar Motion



Universal Time



Y-Pole: Comparisons of techniques to IERS C04



Current characteristics of EOP estimates

Precision gives an estimation of the agreement of various individual solutions with respect to other combined solutions

- Polar motion : 50 -100 μas
- Universal Time: 4- 10 μs
- Nutation offsets: 60 μas

Accuracy reflects the real uncertainties of the solutions taking into account the inconsistency of the EOP system with respect to the terrestrial and celestial frames; inconsistencies, systematic errors, more critical than precision.

- Polar motion : 150 - 200 μas
- Universal Time: 15 - 20 μs
- Nutation offsets: 60 μas

Monitoring reference frames inconsistencies (1)

Various analysis centers of different techniques are deriving EOP and TRF on an operational basis

- –Various techniques, analysis centers, softwares
- –Various methods for attaching the EOP results to the TRF

The IERS EOP-PC makes use of the available EOP results to produce long term EOP series.

The consistency between EOP and reference frames characterizes the « closure » when making the transformation between CRF and TRF via EOP

However separate evolution of EOP and the TRF, it is not surprising that inconsistencies arise ..

What are the causes for the divergence over time between the pole/UT1 defined by the ITRF and the pole/UT1 defined by the continuity of historical EOP series.

Monitoring reference frames inconsistencies (2)

I Usual methods at IERS EOP-PC using rotation angles between CRF and TRF

2 Directly by the comparisons of EOP long-term series

Generate EOP series using ITRF2000 positions and velocities (and ICRF95 source positions for VLBI) as fixed, a priori values.

The resulting EOP from each analysis will thus be forced into consistency with the same ITRF.

- IVS pilot campaign (2000)
- IERS alignment campaign (2002)

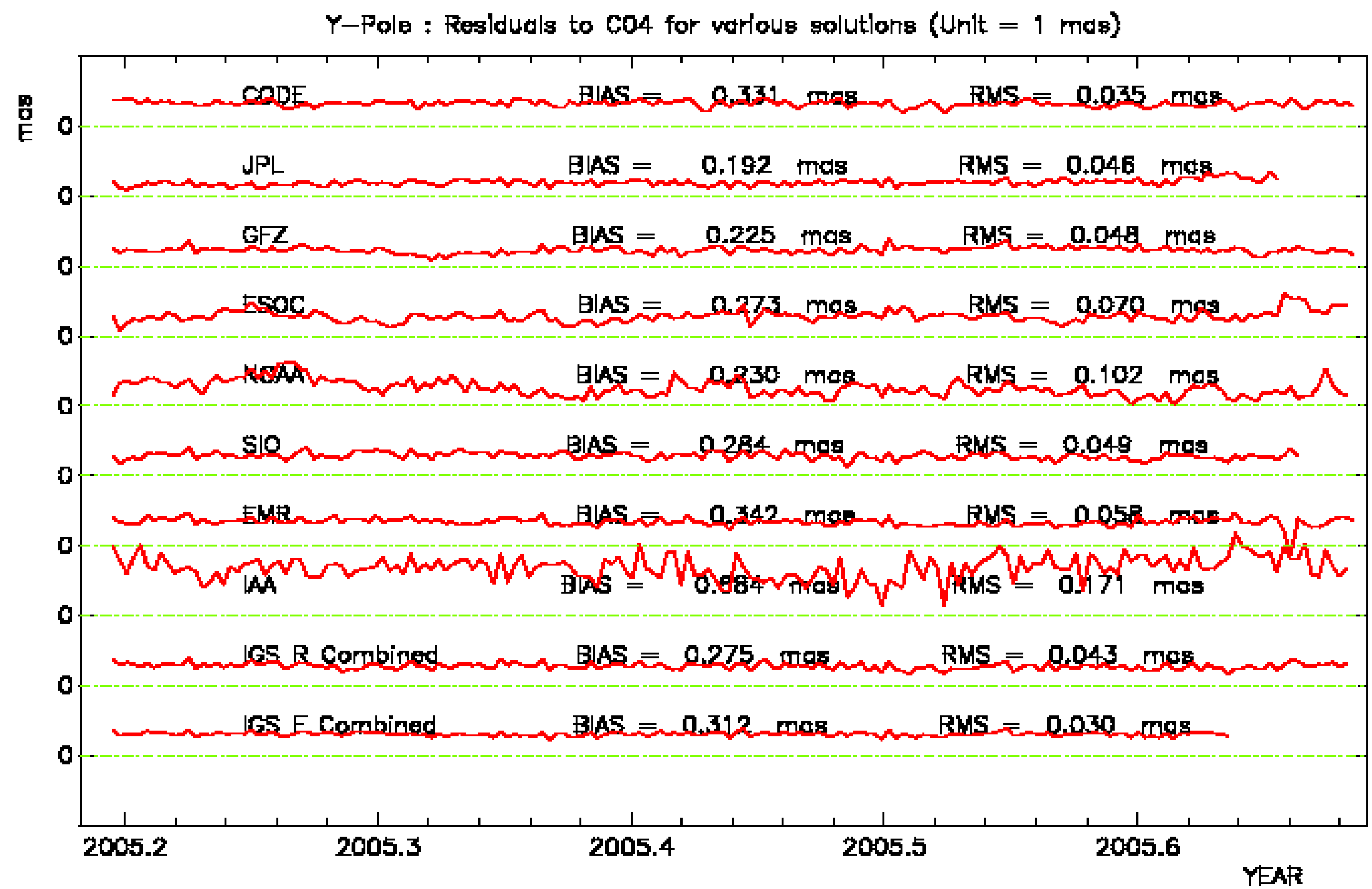
3 Rigorous methods, simultaneous TRF+EOP combinations

➔ different approaches

IERS Pilot Campaign: Bias between individual solutions computed using ITRF2000 and C04

	Institute	Software	Data span	dX (µas)	dY(µas)
	BKG	CALC	1984-2002	-114	143
	GSFC	CALC	1979-2001	-103	148
VLBI	SHA	CALC	1979-2002	-201	194
	DGFI	OCCAM	1984-2002	-135	134
	GAUS	OCCAM	1983-2002	-200	133
	IAA	OCCAM	1980-2002	-138	116
	ASI	GEODYN	1984-2002	-235	110
SLR	IAA	GROSS	1983-2002	-59	58
	CSR	UTOPIA	1976-2002	-366	50
GPS	CODE	BERNESE	1995-2002	44	-35
DORIS	IGN/JPL	GIPSY	1992-2001	1042	377

Y-Pole: residuals GPS series – C04 (μas)

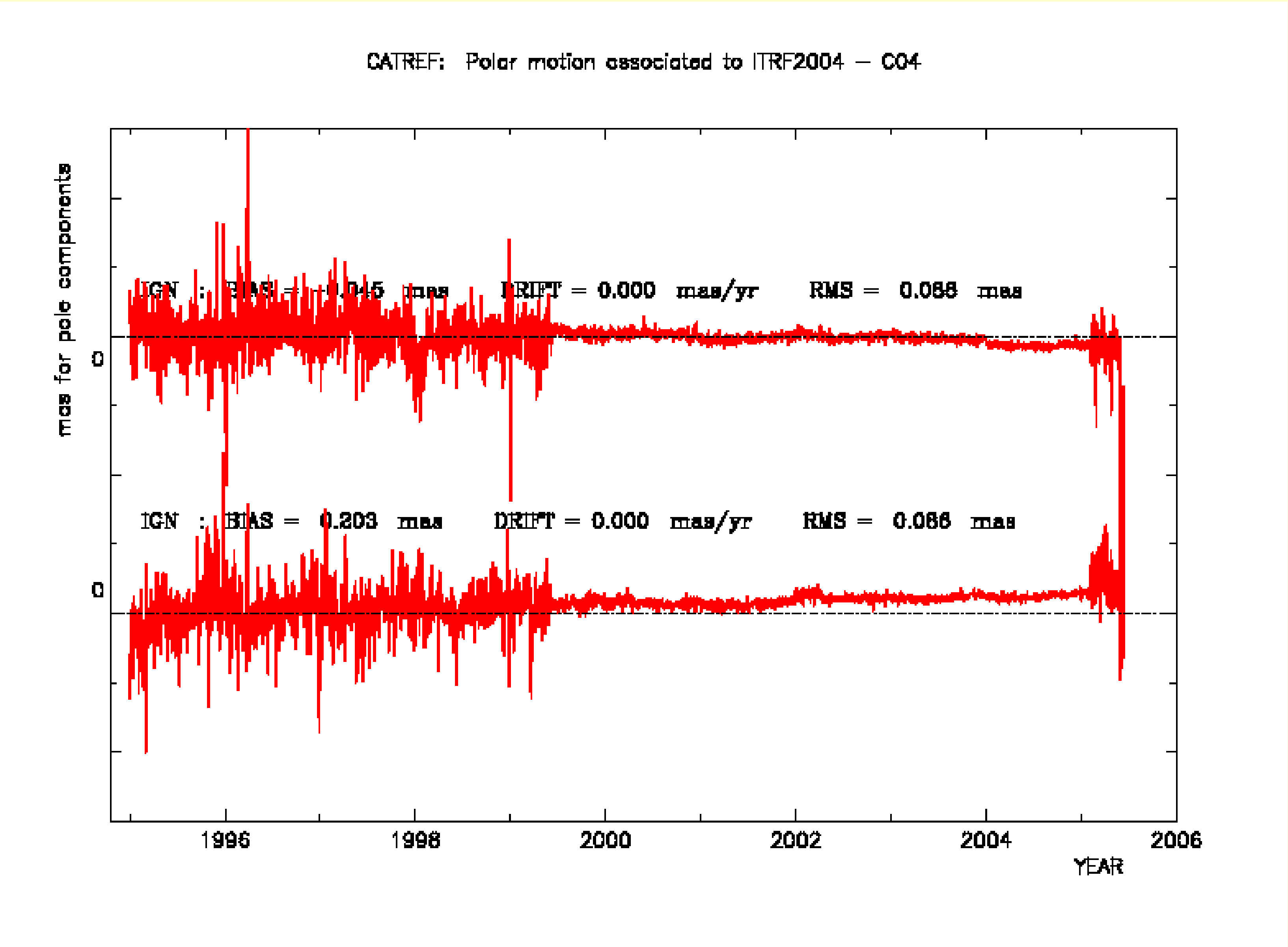


Agreement for Y-pole between individual GPS and C04 (μas)

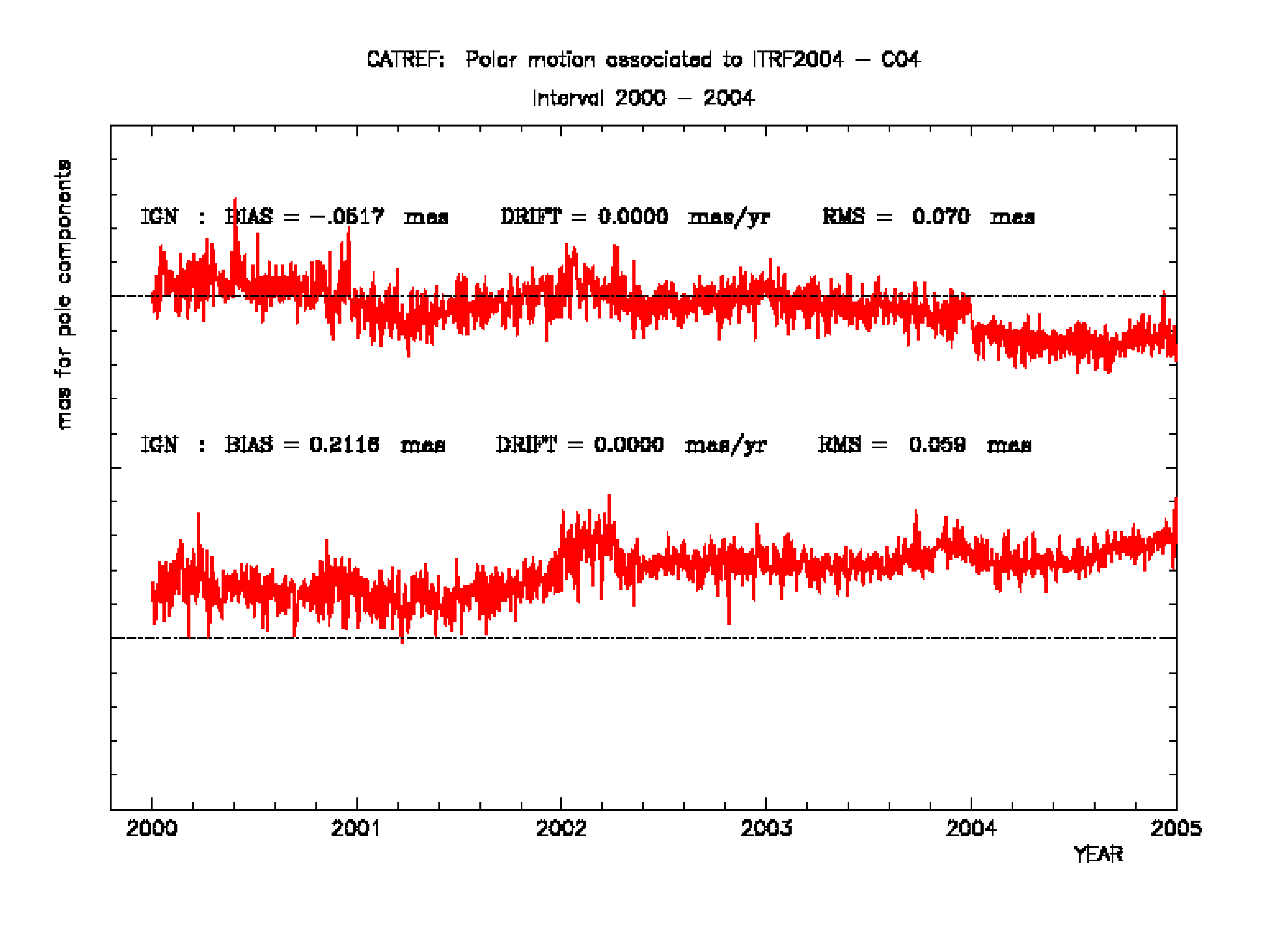
Analysis Center	Bias	RMS
CODE	328	32
JPL	197	44
GFZ	226	47
ESOC	273	65
NOAA	227	102
SIO	283	48
EMR	350	46
IGR	273	41
IGS	311	23

Diff=150 μas

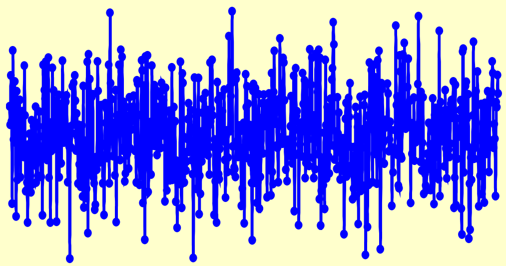
CATREF : Polar motion associated with ITRF2004 and C04



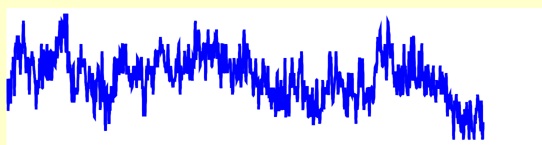
CATREF : Polar motion, zoom over 2000 - 2005



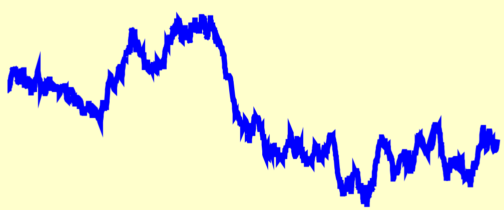
Noise caracteristics in the time domain



White phase
noise modulation

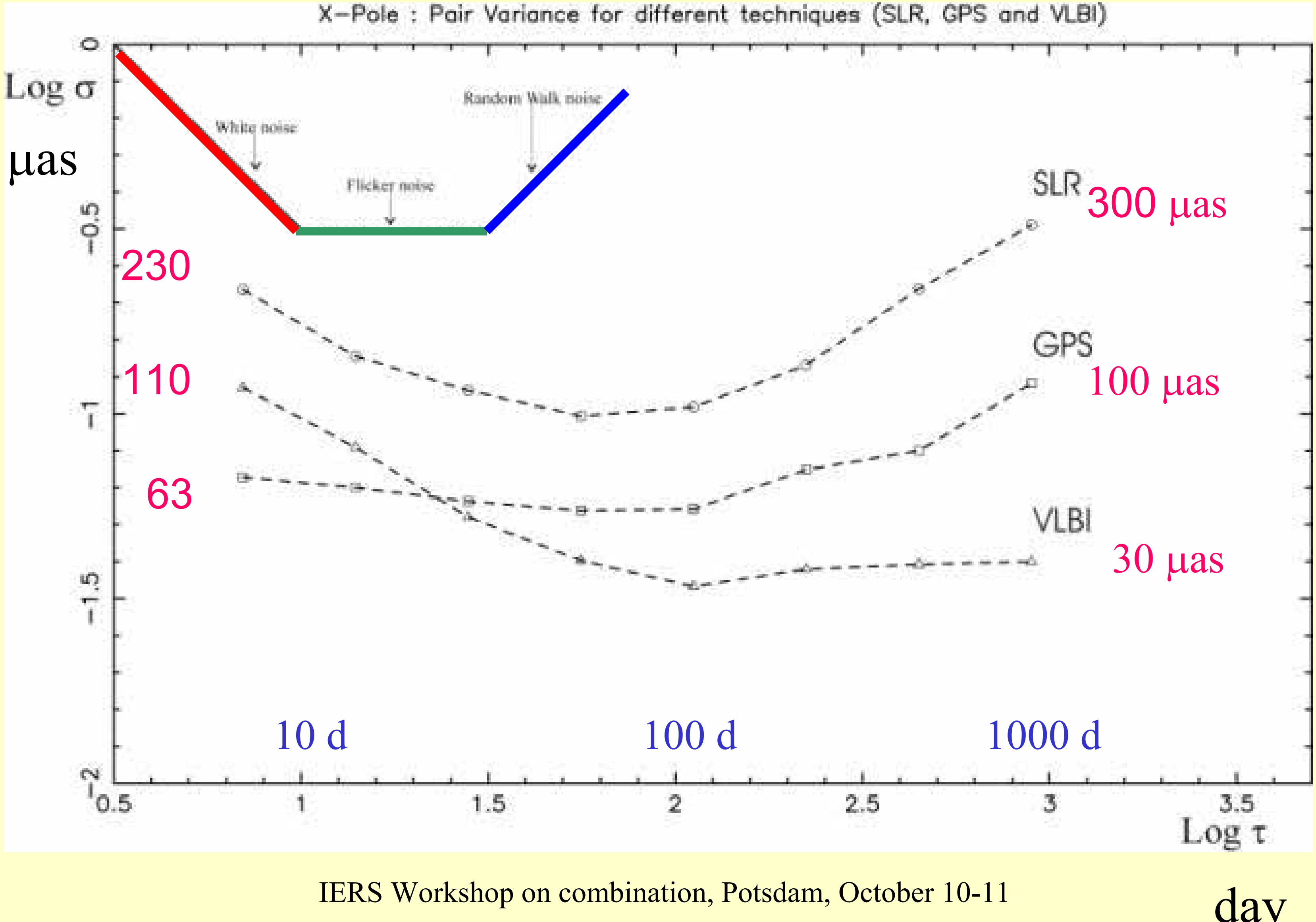


Flicker phase
noise modulation



Random-walk phase
noise modulation

Allan variance analysis for SLR, GPS and VLBI



Revised version of the algorithm performing C04 solution

- Since 2002 reprogramming of the Fortran Code of the C04 solution

- New CODE should be operational from 2005 November 1rst.

What is new ? :

-Implementation of the nutation model IAU 2000

-Solution can be performed over 20 years in one run

-New approach for combination of LOD (GPS), compatible with UT1-UTC.

-Estimation of errors

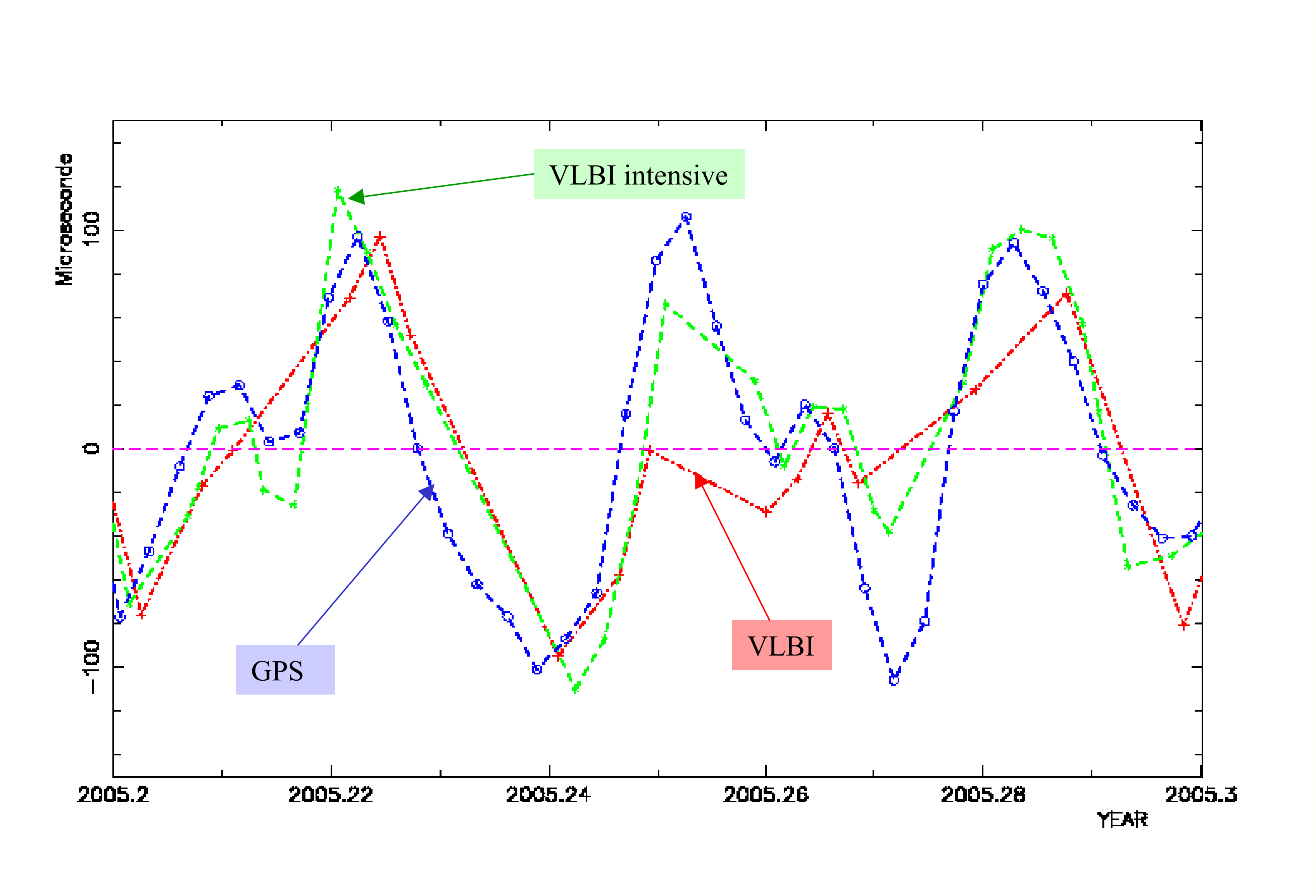
-Automatized daily solution

Performance of the new algorithm of combination

RMS agreement with C04

- GPS Polar motion : no significative change (slight degradation of 2-3 μas)
- VLBI polar motion : 7-10 μas improvement
- UT1 : up to 1-2 μs improvement
- Celestial pole offsets (for 8 series) : mean improvement 10 μas (up to 20 μas)
- GPS LOD : 6 μs improvement
- Short-term prediction using AAM forecasts

UT: High frequency variations VLBI, VLBI intensive and GPS



Use of GPS LOD for deriving real time UT1

VLBI series available with a time latency of

A week or two for standard solution

A few days to one week for VLBI intensive

For UT1 real-time estimation LOD(GPS) is used to derive

1) A long-term integrated UT solution (available since 1995)

rms = 30 μs

2) Real time estimates of UT1

mean accuracy = 35 μs

UT short-term prediction using Atmospheric Angular Momentum forecasts

Many applications like satellite positioning, telecopes pointing require good prediction of EOP, currently 1 mas for polar motion and 100 μs for UT1

Below 10 days, UT1 variations are due to the exchange of angular momentum between the atmosphere and the crust.

AAM forecasts daily derived by various centers (4-7 days)

UT short-term prediction using Atmospheric Angular Momentum forecasts

Prediction horizon in day	UKMO µs	NMC µs	JMA µs	IERS C04 Current predictions µs
4 days	300	300	150/200	300/400
7 days	-	-	250/400	800/1000

Prediction skill in µs

Conclusions

- At least 3 comparable techniques necessary to perform EOP combined solution
- Short-term accuracy of GPS is the best one for polar motion
- However long-term stability of VLBI better than GPS
- Need for a different weighting according to the scale, short and long-term
- The inconsistency of C04 will be removed using the EOP solution derived with ITRF2004 (CATREF)