The 2nd of June, 2015
at Toulouse, France

Actual situation of nutation : Comparison between official VLBI solutions

SF2A 2015

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l'Observatoire de Paris | SYRTE

Systèmes de Référence Temps-Espace

Introduction

FIELD : Geodetic Very Long Baseline Interferometry

Purpose of the thesis :

Astrometric :

Situation :

ICRF2 (soon ICRF3) Cf « The second Realization of the International Celestial Reference Frame by Very Long Baseline Interferometry », IERS technical note no.35

Geodesic :

Precession-nutation

Earth Rotation

ITRF

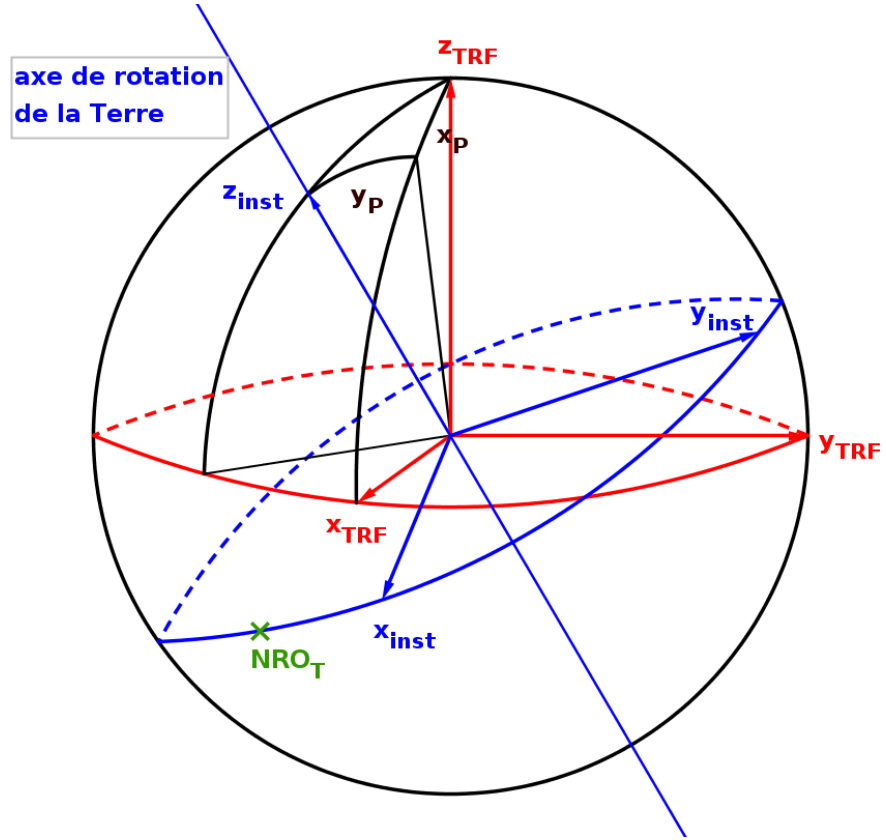
Some basic knowledge

[CRF] = PN . A . PM [TRF]

Where **PN**, **A** and **PM** are rotation matrix products.

PM allows to change :

- From the terrestrial reference frame
- To the immediate frame of the date
  (having as pole the Earth rotation pole and possessing a non-rotating origin according to the Earth crust)



⇒ **Earth Polhodie**

- Parameter : x_p and y_p

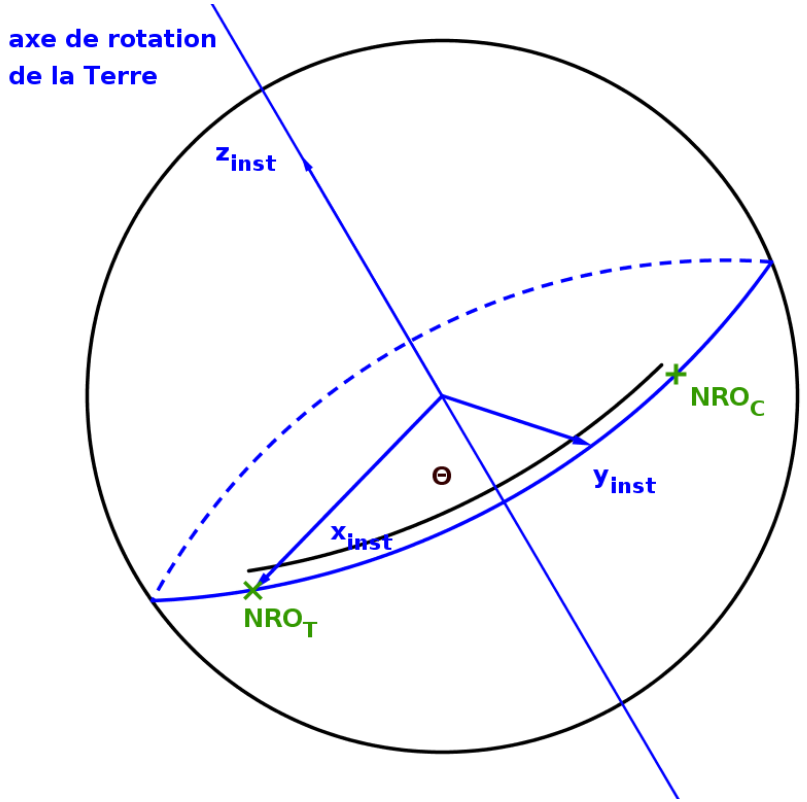
Some basic knowledge

[CRF] = PN . A . PM [TRF]

Where **PN**, **A** and **PM** are rotation matrix products.

A allows to change :

- From the immediate frame of the date
  (having as pole the Earth rotation pole)
  - Non-rotating origin according to the Earth crust
- To the immediate frame of the date
  (having as pole the Earth rotation pole)
  - Non-rotating origin according to the celestial sphere



⇒ Earth rotation angle

- Parameter : **UT1**

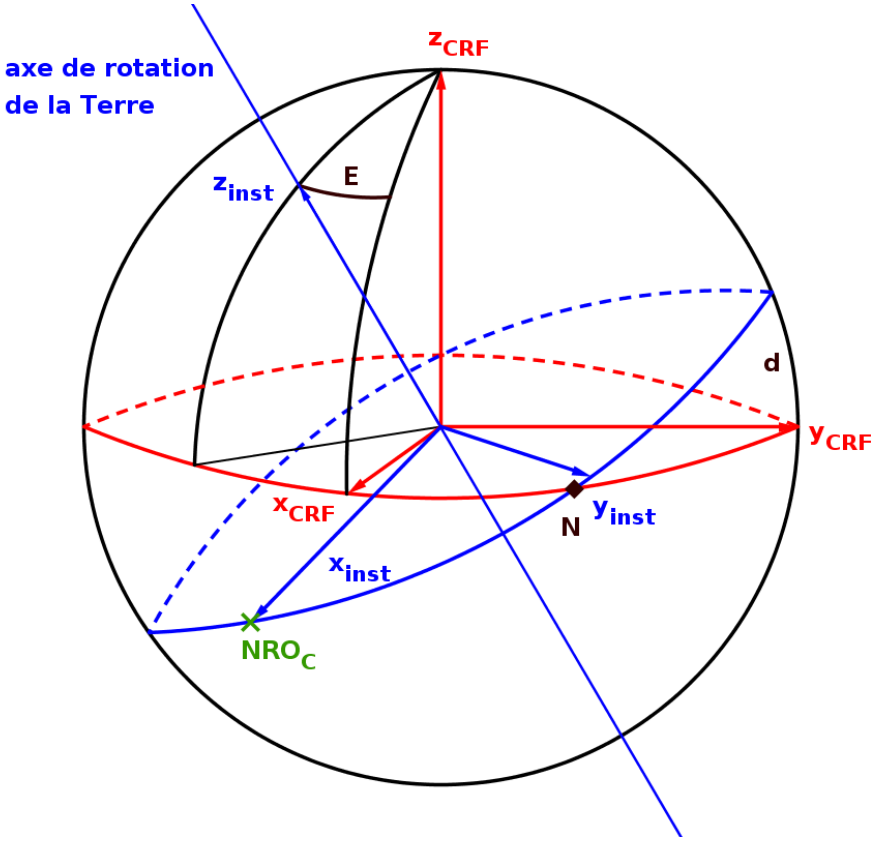
Some basic knowledge

[CRF] = PN . A . PM [TRF]

Where **PN**, **A** and **PM** are rotation matrix products.

PN allows to change :

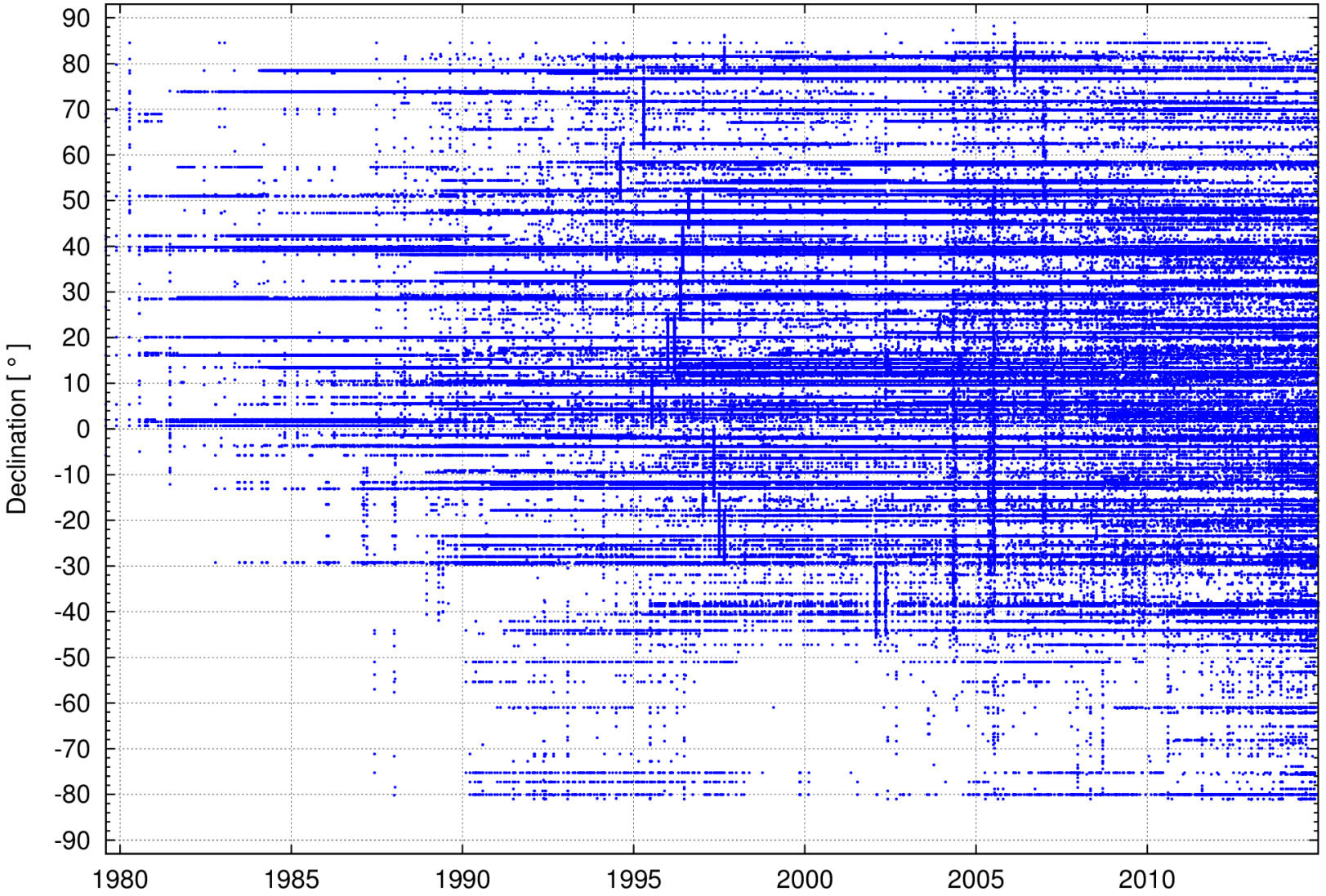
- From the immediate frame of the date *(having as pole the Earth rotation pole and possessing a non-rotating origin according to the celestial sphere)*
- To the celestial reference frame



⇒ **Precession-nutation**

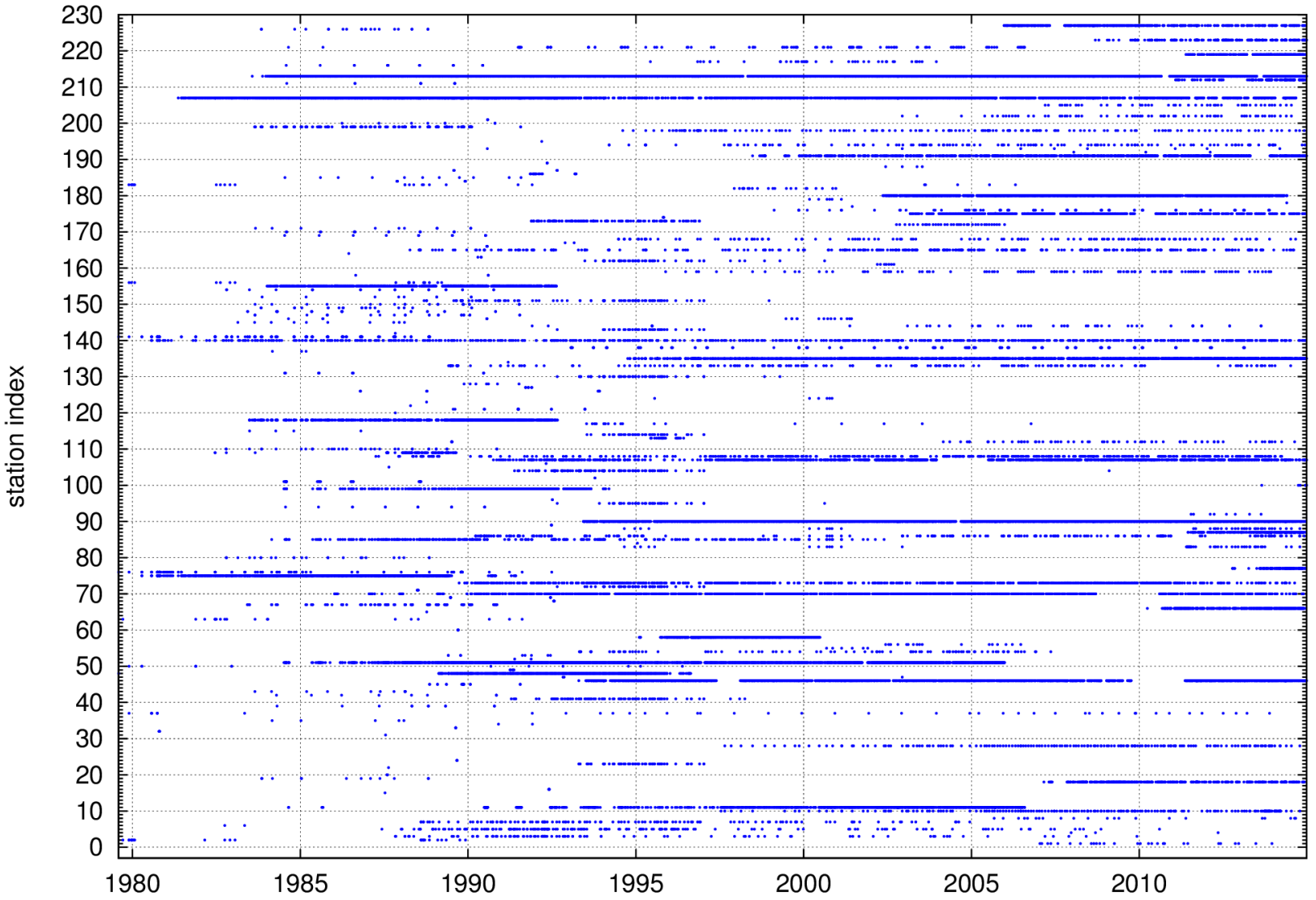
- Parameters : **X** and **Y**

AVAILABLE SET OF DATA



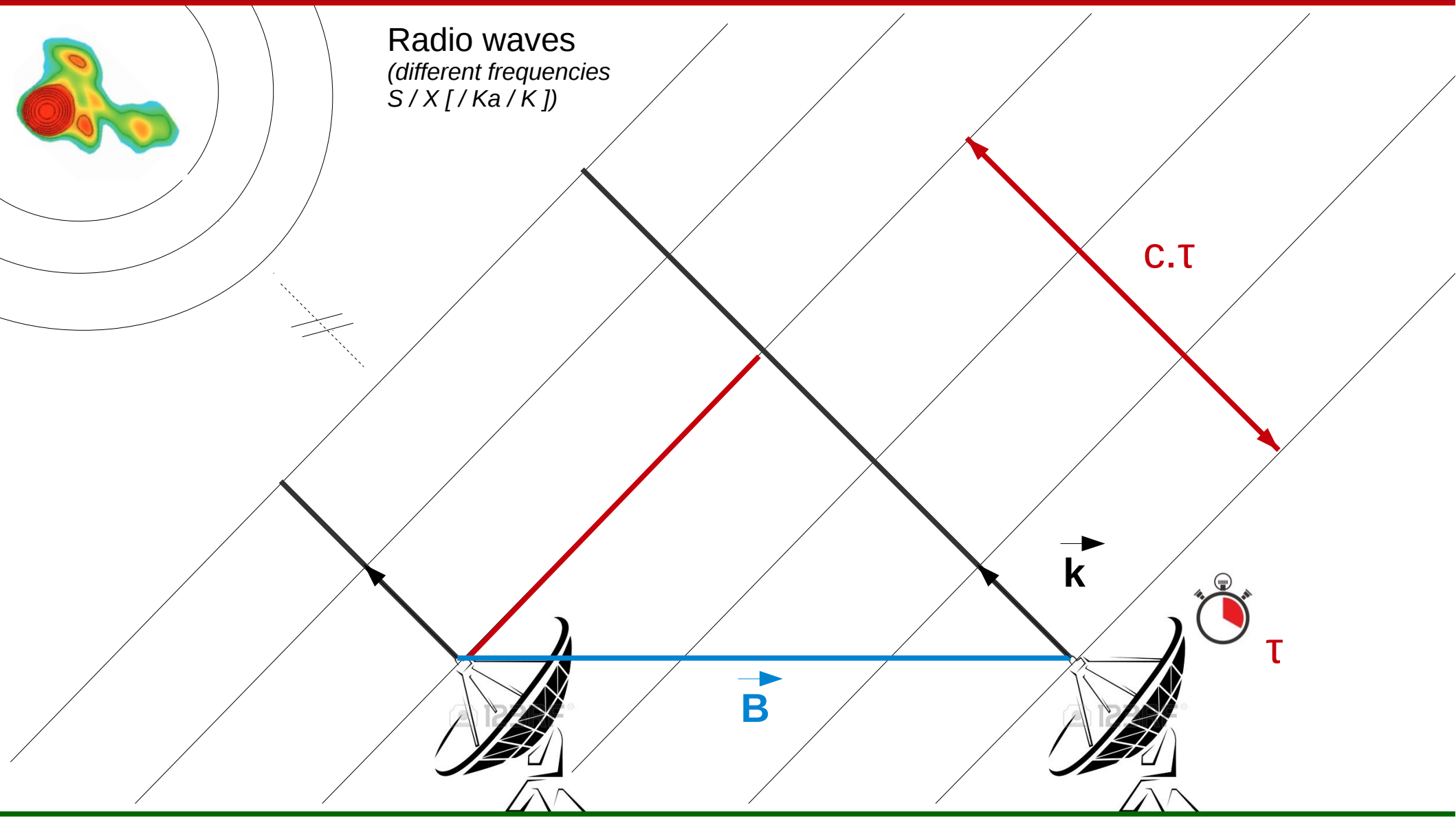
- **35** years of observation (up to 24h duration)
- ~ **8000** VLBI sessions
- **5771** radiosources

AVAILABLE SET OF DATA

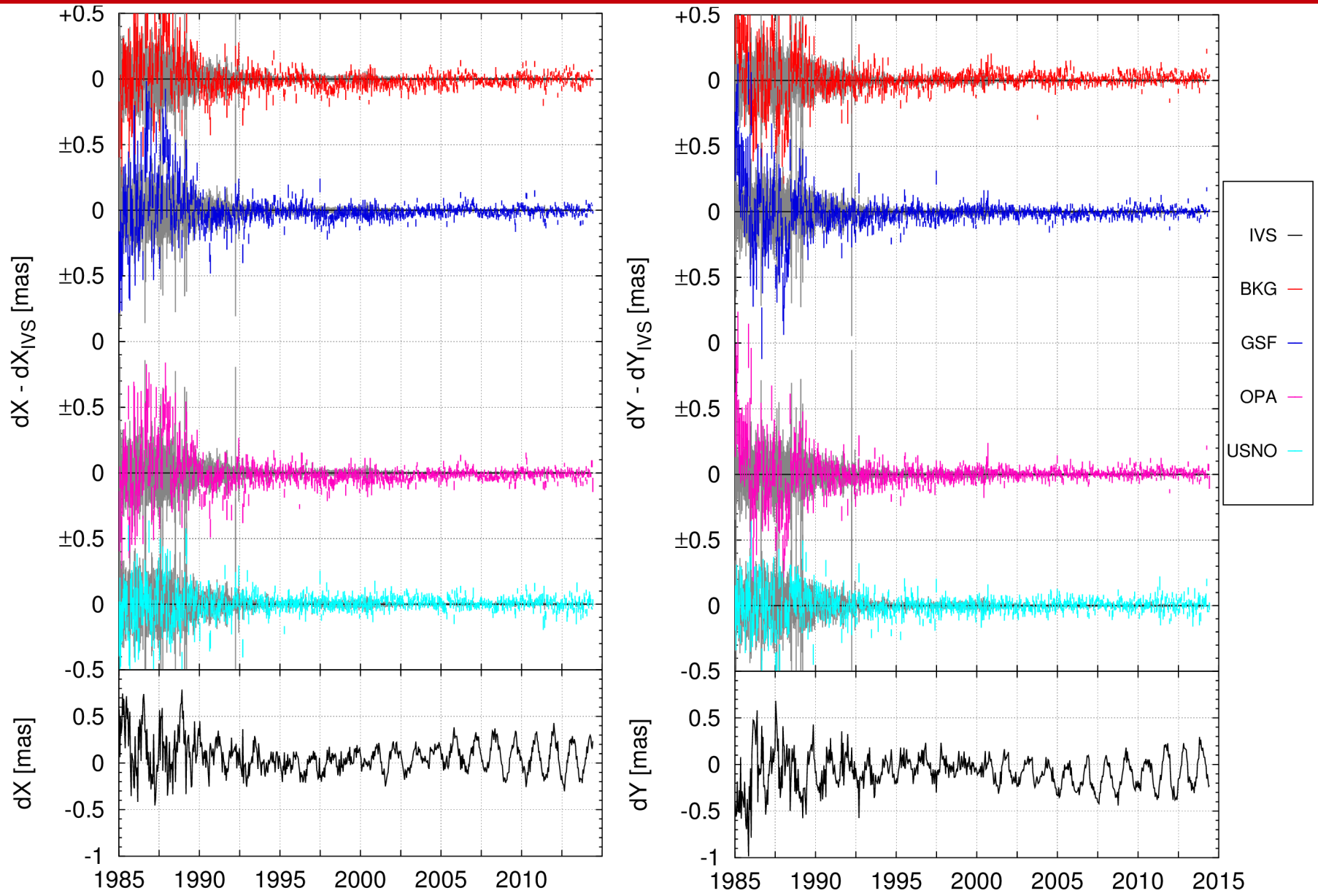


- **35** years of observation (up to 24h duration)
- ~ **8000** VLBI sessions
- **227** stations (fixed and mobile)

What is the VLBI principle ?



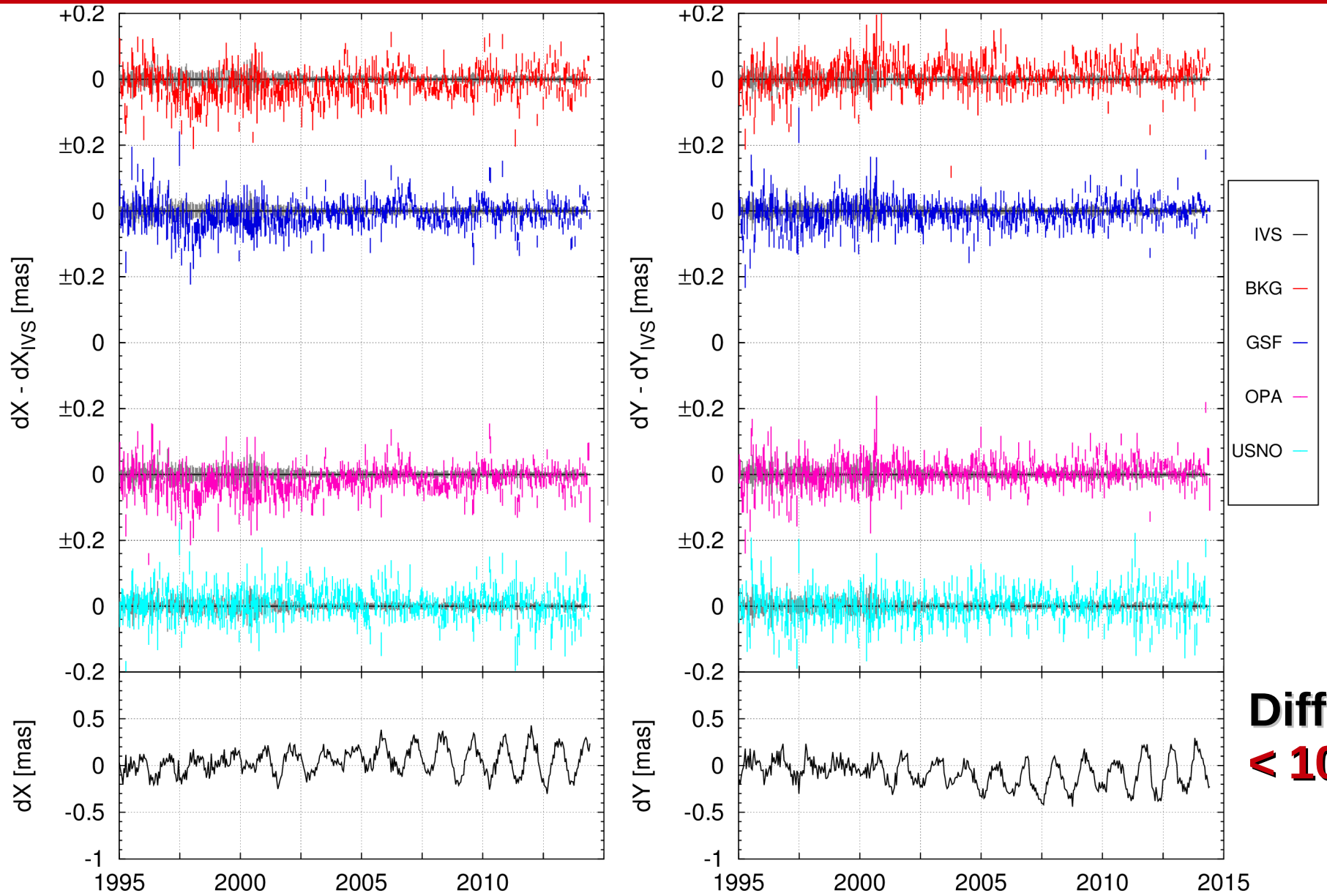
IERS Nutation Time Series - Comparison



- Smoothed over 15 days
- errorbars for smoothed data are non inflated !

(some use 1.5 inflation)

IERS Nutation Time Series - Comparison

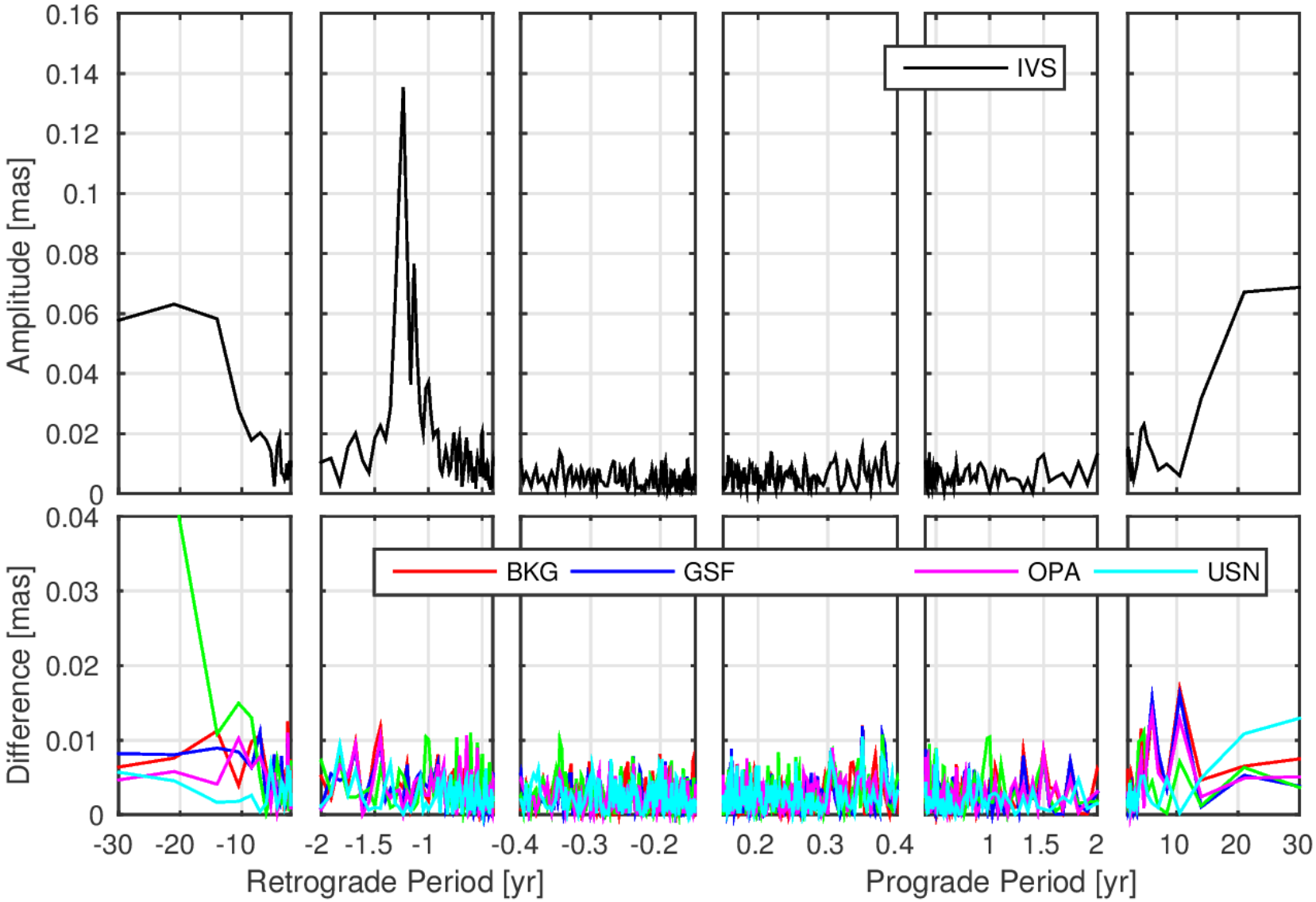


- Smoothed over 15 days
- errorbars for smoothed data are non inflated !

(some use 1.5 inflation)

Differences : < 100 µas

IERS Nutation Time Series - Spectra

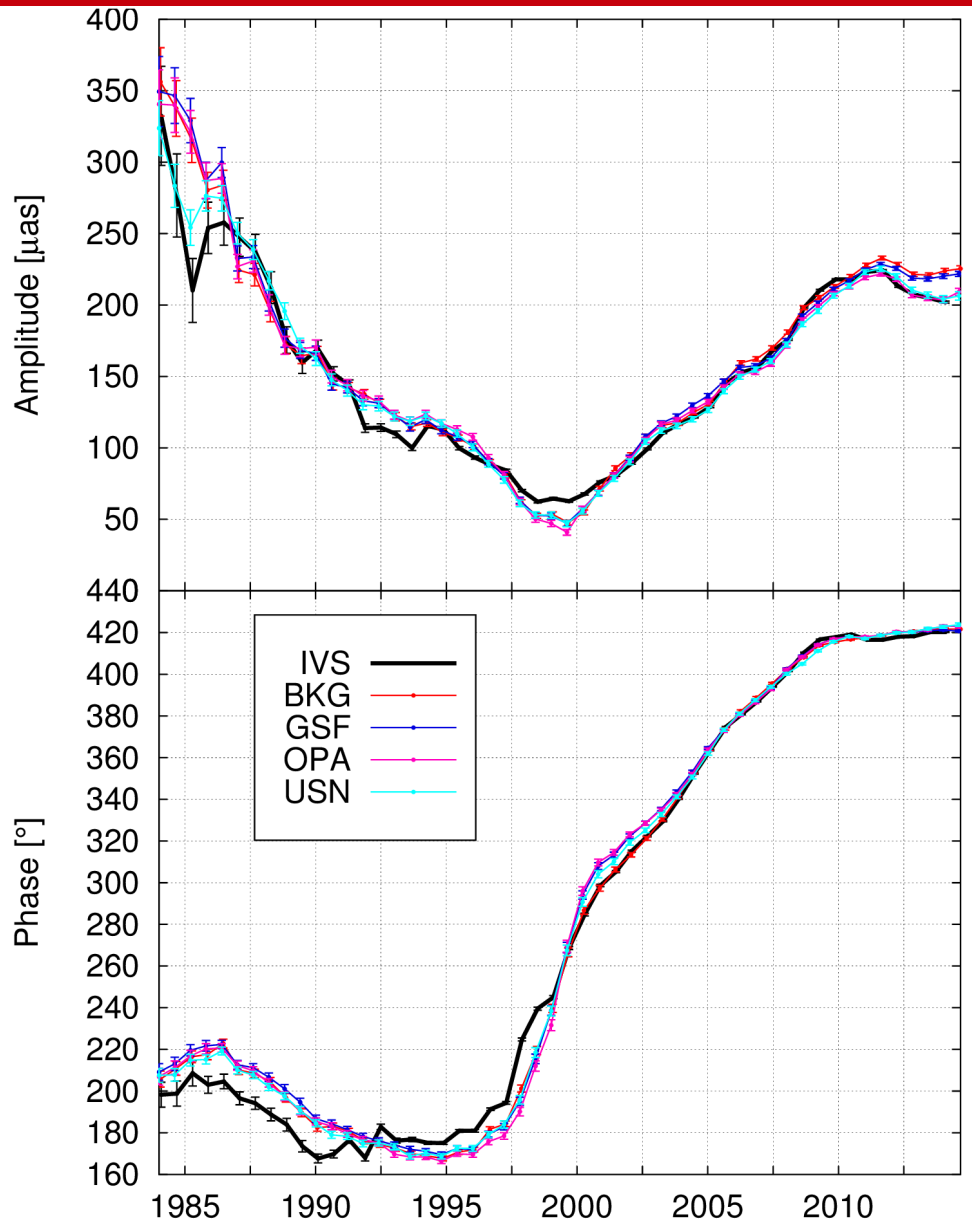


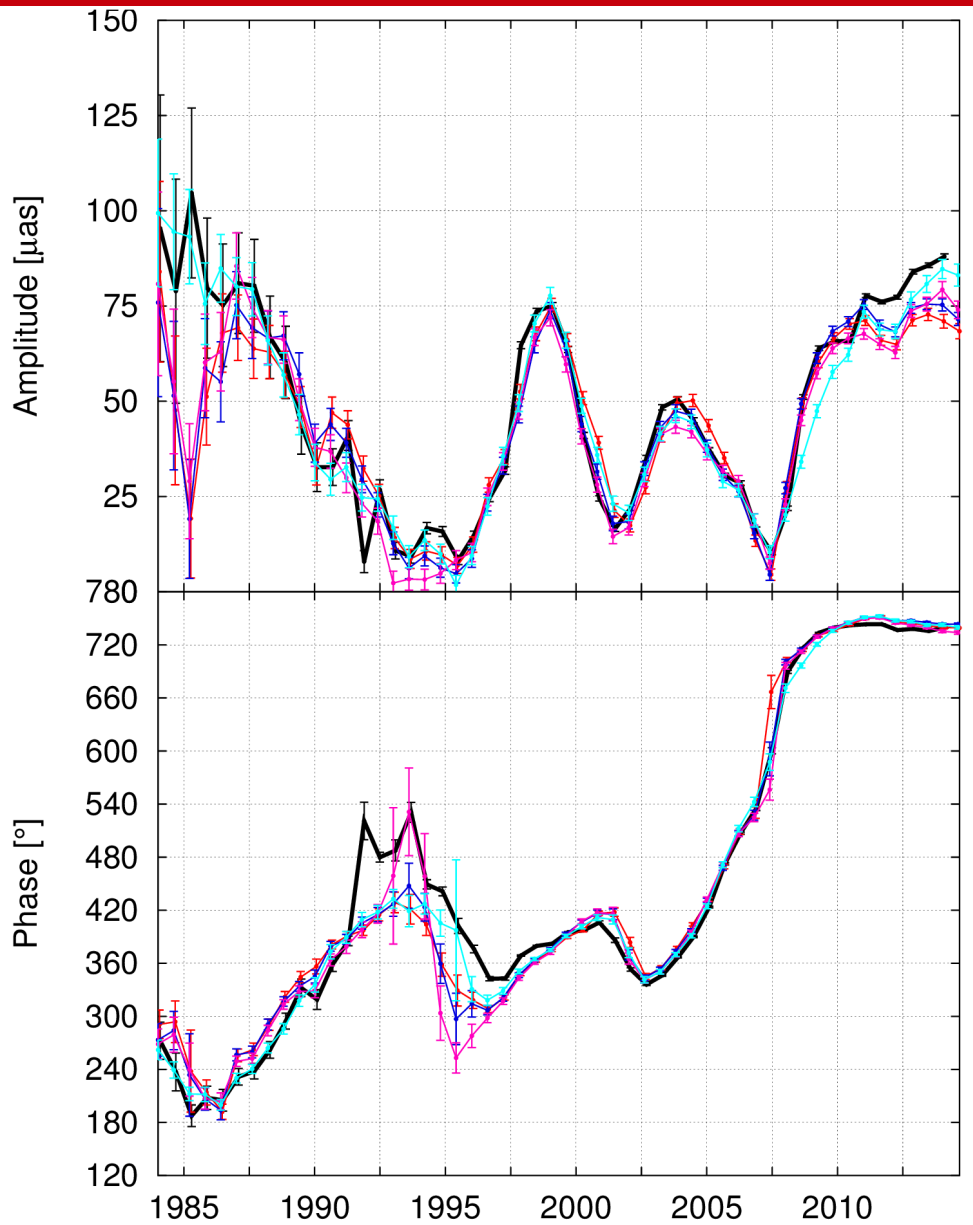
Amplitude differences :

< 10 µas for periods **< 2 years**

< 20 µas for periods **> 2 years**

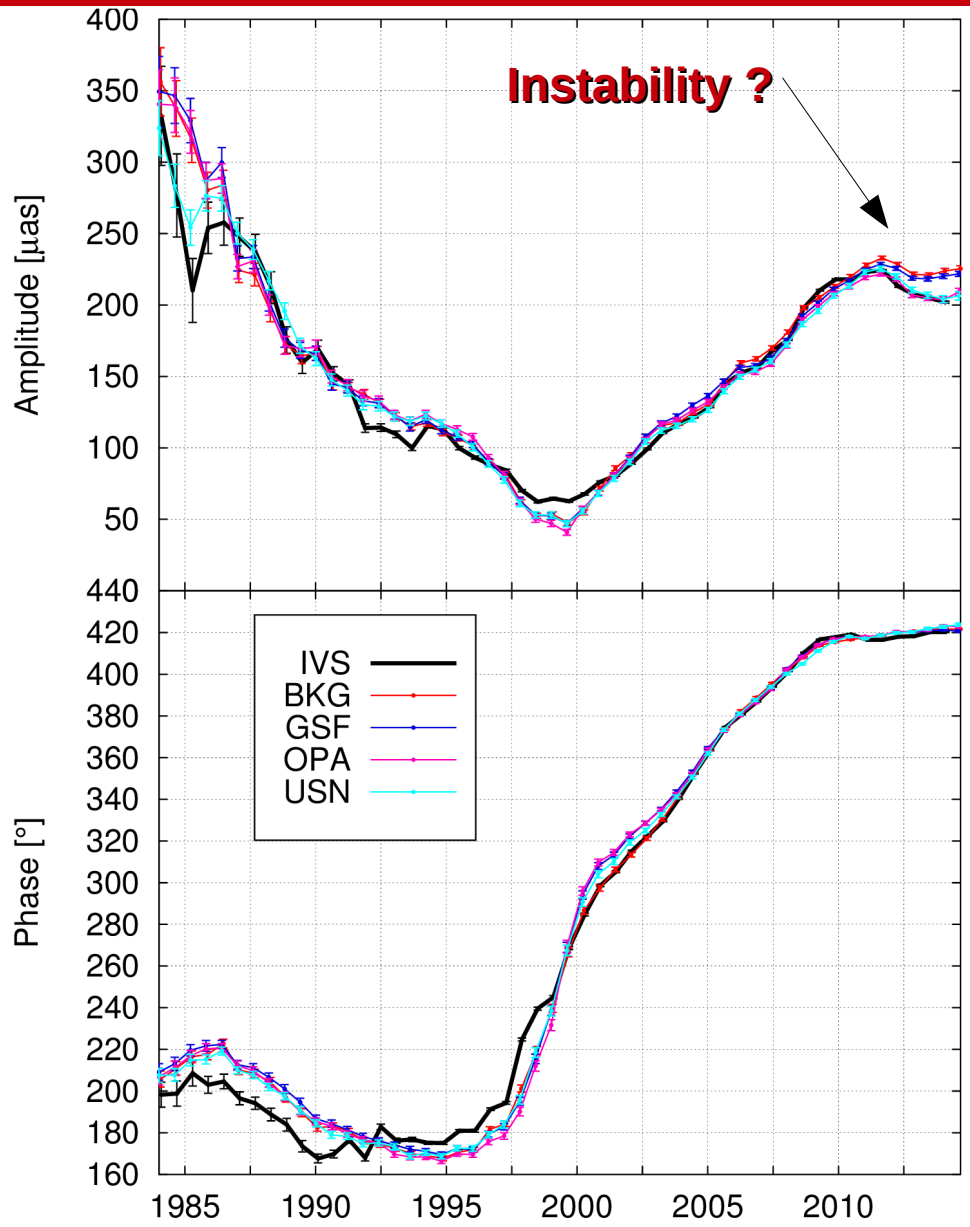
Free Core Nutation and Annual nutation Adjustements

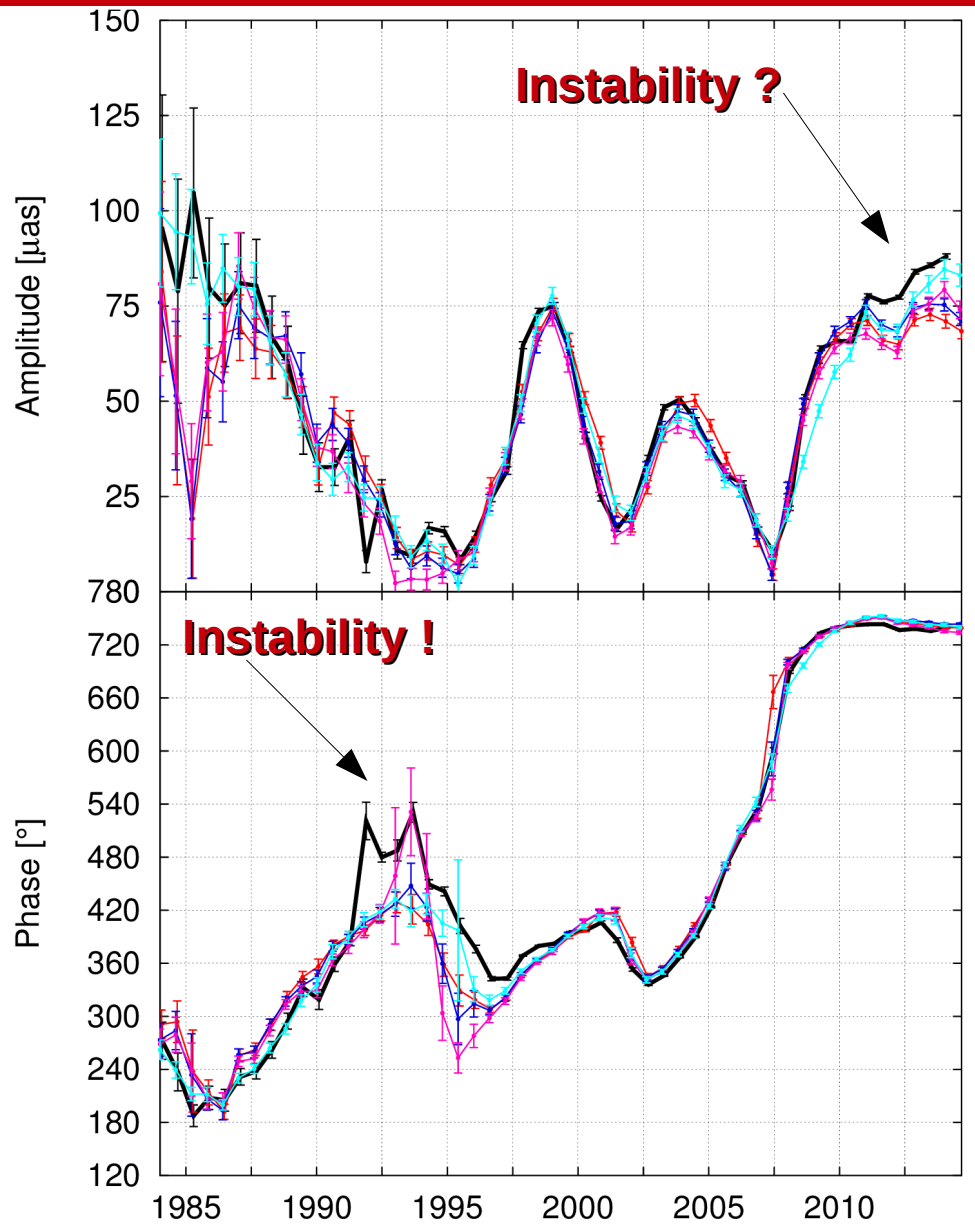




Stable over **10 µas** (amplitude), **10°** (FCN phase), **30°** (Annual Phase)

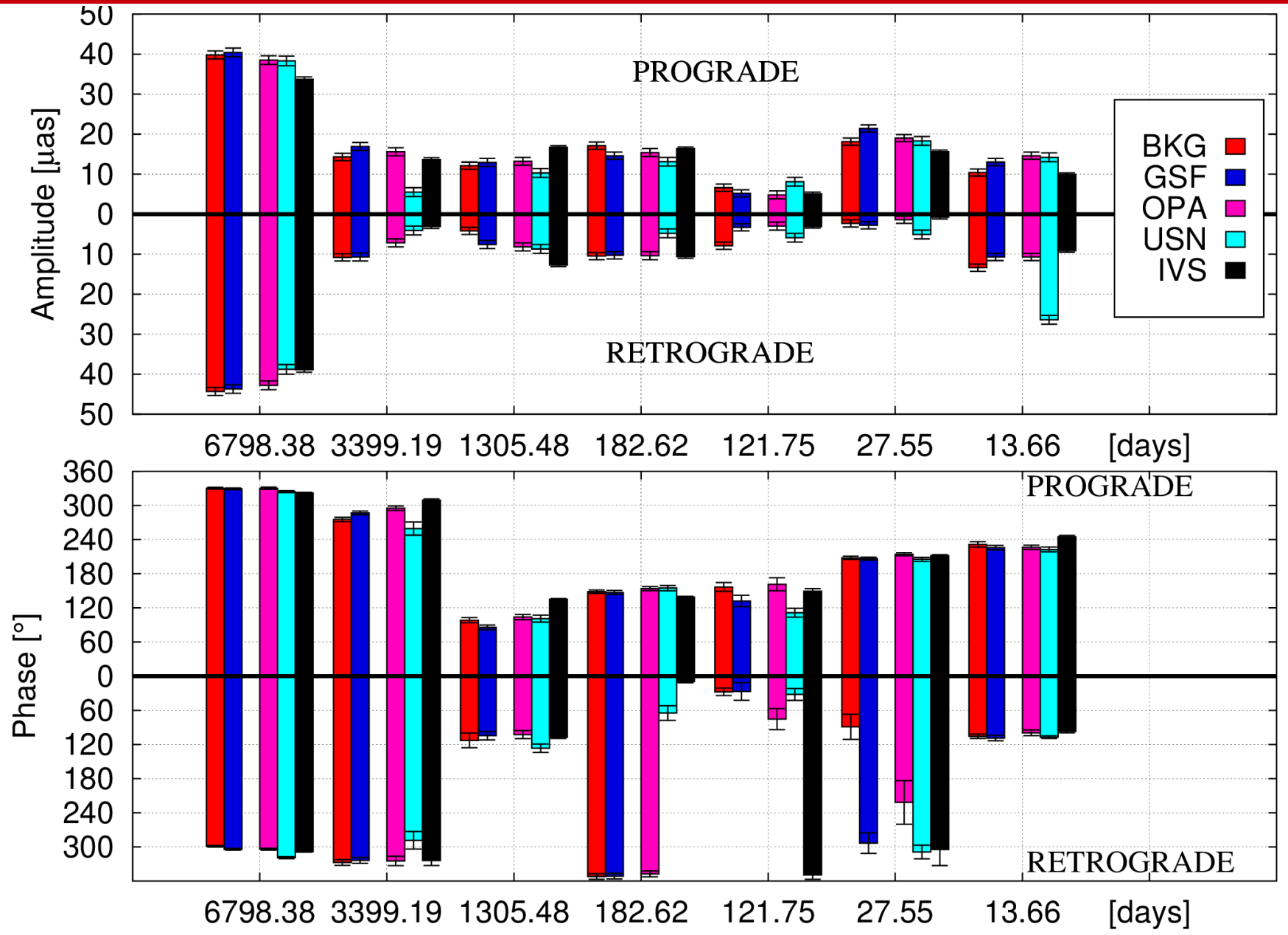
Free Core Nutation and Annual nutation Adjustements





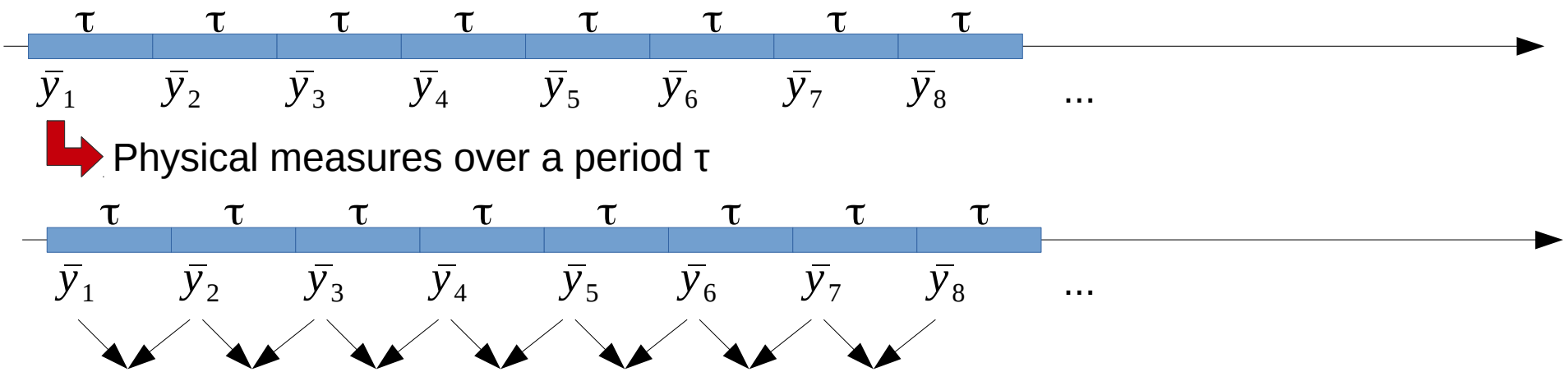
Stable over **10 µas** (amplitude), **10°** (FCN phase), **30°** (Annual Phase)

Others Principal Nutation Adjustements



IERS Nutation Time Series – Allan variance

Theoretical knowledge :



Physical measures over a period τ

$$\frac{1}{2}\left(\bar{y}_k - \bar{y}_{k+1}\right)^2 = \sigma^2_{(2)}(\tau) \quad \Rightarrow \quad \left\langle \sigma^2_{(2)}(\tau) \right\rangle$$

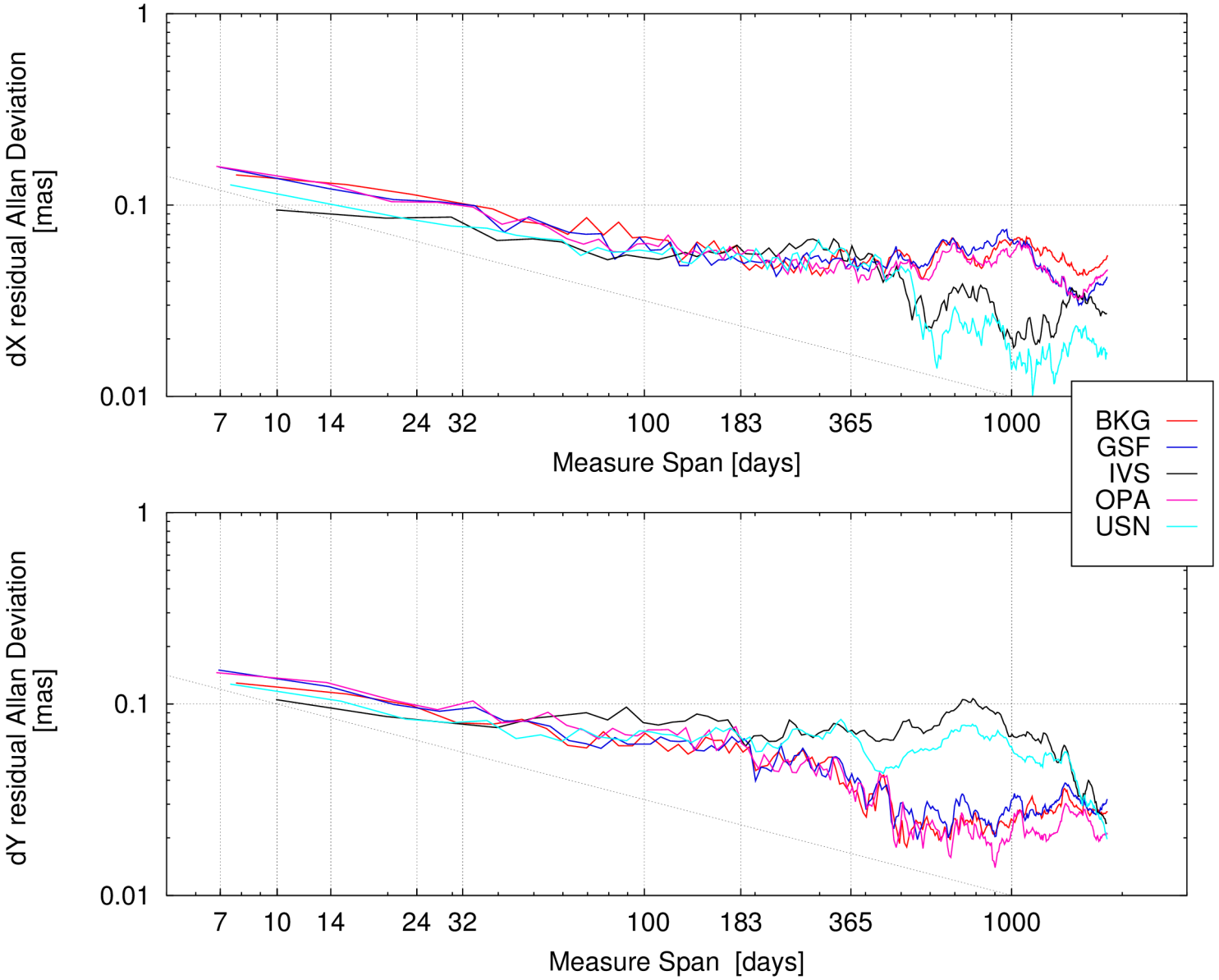
Allan Variance measurement

Estimation of the true variance of the data set given τ

The Allan variance serie with respect to τ allow to :

- **determine the type of noise associated with datas**
- **estimate the true variance of datas**

IERS Nutation Time Series – Allan Deviation



Result :

Flicker Noise
+
periodic signal at long period
(> 5 years)

Or

White Noise
+
Outliers

Remark : A rejection of outliers has been done beforehand

Center Analysis Strategy

	BKG	GSF	OPA	USN
CRF	a priori **ICRF2** NNR 295 Def. sources ?? global / ?? local	A priori **gsf2012a.src** NNR 295 Def. sources 1670 global / 39 local	A priori **ICRF2** NNR 295 Def. sources ?? global / 39 local	A priori **ICRF2** NNR 295 Def. sources 846 global / 852 local
Nutation	A priori **IAU2006/2000A** Apply recommandation **IERS Convention 2010**	A priori **IAU2006/2000A** Apply recommandation **IERS Convention 2010**	A priori **IAU2006/2000A** Apply recommandation **IERS Convention 2010**	A priori **IAU2006/2000A** Apply recommandation **IERS Convention 2010**
Tropo	Zenith : **1h linear spline** VMF1 wet partial derivative (segmented) A priori made by make_vmf_trp_file from GSFC **based on VMF1** Gradient : East and north **offset** A priori **from DAO model**	Zenith : **20-min linear spline** VMF wet partial derivative (segmented) A priori **VMF total mapping function** Saastamoinen model Gradient : **6-hour linear spline** east and north A priori **from DAO model**	Zenith : **20-min linear spline** A priori **VMF1 mapping function** Gradient : **6-hour** east and north **offset** A priori **from DAO model**	Zenith : **20-min linear spline** NMF wet partial derivative (segmented) A priori **NMF dry mapping function** Saastamoinen model Gradient : **6-hour linear spline** at all station except 110 A priori **from DAO model**
Clock	1h linear spline	Quadratic (local) + 1h linear spline (segmented)	Quadratic (local) + 1h linear spline	Quadratic (local) + 1h linear spline
Elevation cutoff	5° elevation cutoff	5° elevation cutoff	5° elevation cutoff	5° elevation cutoff
Software	CALC 11.01 Solve 2014.02.21	CALC 11 SOLVE 2014.02.21	CALC 11.0 SOLVE 2014.02.21	CALC 11 SOLVE 2014.02.21

Conclusion

- There exist differences between nutation time series of IERS **at the order of 100 µas**
- Those are consequences of differences in nutation adjustements **at the order of 10 µas** in amplitude and **at the order of 10-30°** in phase
- Residuals after adjustements seem to be animated by a **flicker noise** with a periodic signal at long period (> 5 years)
- Signal are stable **at 100 µas over 7 days** and at **few tenth of µas over period of several years**

Thanks

I thank you for your attention

If you want to contact me :

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