Analysis of Geocenter Time Series derived from SLR, GPS and DORIS

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Time series describing geocenter motion

The times series at daily, weekly or monthly intervals are obtained by either of the following equivalent methods.

Dynamic method: C_{11}, S_{11}, C_{10}

Estimated ***degree-one terms*** of the spherical harmonic expansion of the gravitational potential. Quality of the results depends on the accuracy of the orbit, which in turn requires a complete and accurate force model.

Geometric method: Tx, Ty, Tz

Translation parameters between the ***successive terrestrial reference frames*** and a conventional TRF (here ITRF2000). Results are sensitive to the terrestrial network geometry changes.

C_{11}, S_{11}, C_{10} are proportional respectively to Tx, Ty, Tz

The series analysed

Techn.	Center	Author	Intrv	Method
SLR	ASI	C. Luceri	Week	Dynamic
Source: luceri@asi.it				
DORIS	IGN-JPL	P. Willis	Week	Geometric
ftp://lareg.ensg.ign.fr/pub/doris/products/geoc/ign02wd02.geoc.Z				
DORIS	LEGOS-CLS	L. Soudarin	Month	Geometric
ftp://cddisa.gsfc.nasa.gov/doris/products/sinex_series/lcamd/				
GPS	JPL	M. Heflin	Day	Geometric
ftp://sideshow.jpl.nasa.gov/pub/mbh/				

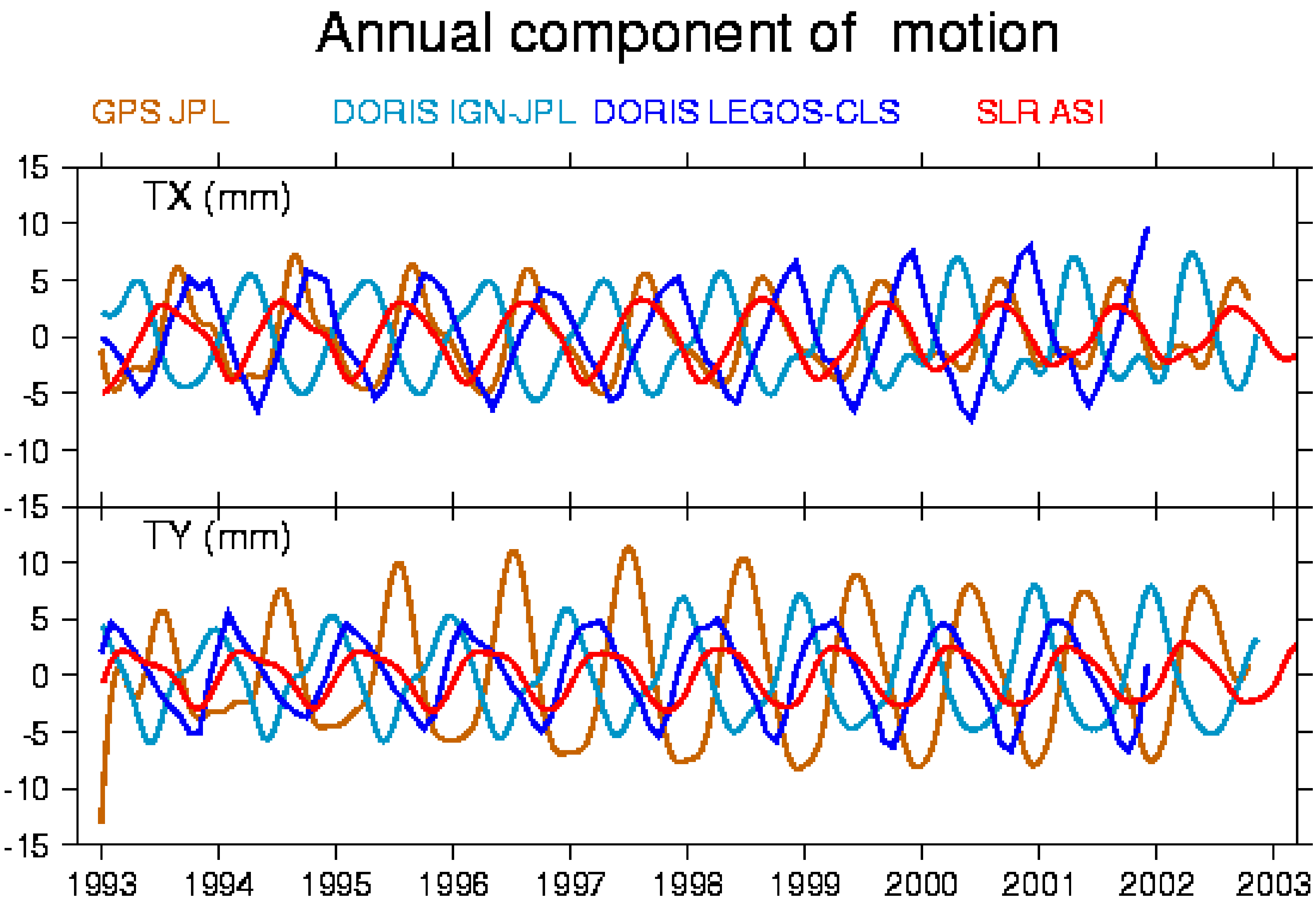
Extracting low frequency and seasonal components using the Census X11 filter

The Census X11 filter splits a time series into three components: *trend, seasonal,* and *irregular.* The filtering involves only running averages and reweighting of outliers. The only constraint on the seasonal component is a fixed period. The sum of the three components is equal to the initial series at each date.

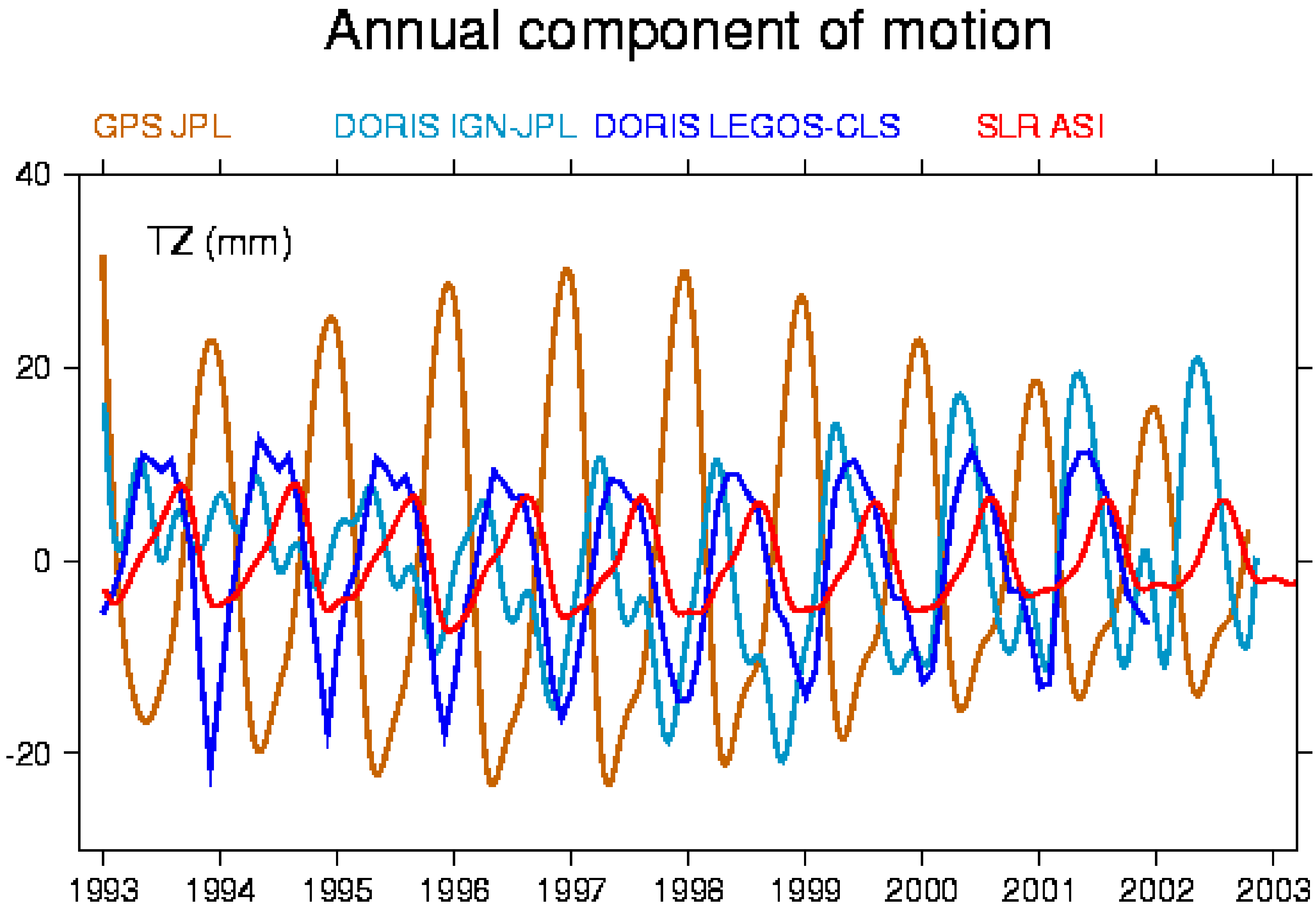
Characterizing the signal spectrum by the Allan variance

The Allan variance is a stability estimator commonly used to quanlify and quantify the atomic clocks stability. It offers diagnoses for spectral density laws such as *white noise*, *flicker noise* (spectral density ~1/frequency) and *random walk* (spectral density ~1/squared frequency).

The Allan variance is sensitive only to the stochastic part of the signal.



Annual component of motion
GPS JPL
DORIS IGN-JPL
DORIS LEGOS-CLS
SLR ASI
TX (mm)
TY (mm)
15
10
5
0
-5
-10
-15
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003


Annual component of motion
GPS JPL
DORIS IGN-JPL
DORIS LEGOS-CLS
SLR ASI
TZ (mm)
40
20
0
-20
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003

Seasonal variations

Equatorial components

Amplitudes of the **SLR**, **Doris** and **GPS** signals at similar level:
1 cm peak-to-peak.

Axial component

Amplitudes of the **SLR** and **Doris** signals at similar level:
3 cm peak-to-peak.
Larger amplitude for **GPS** before 2000: ***5 cm peak-to-peak***.

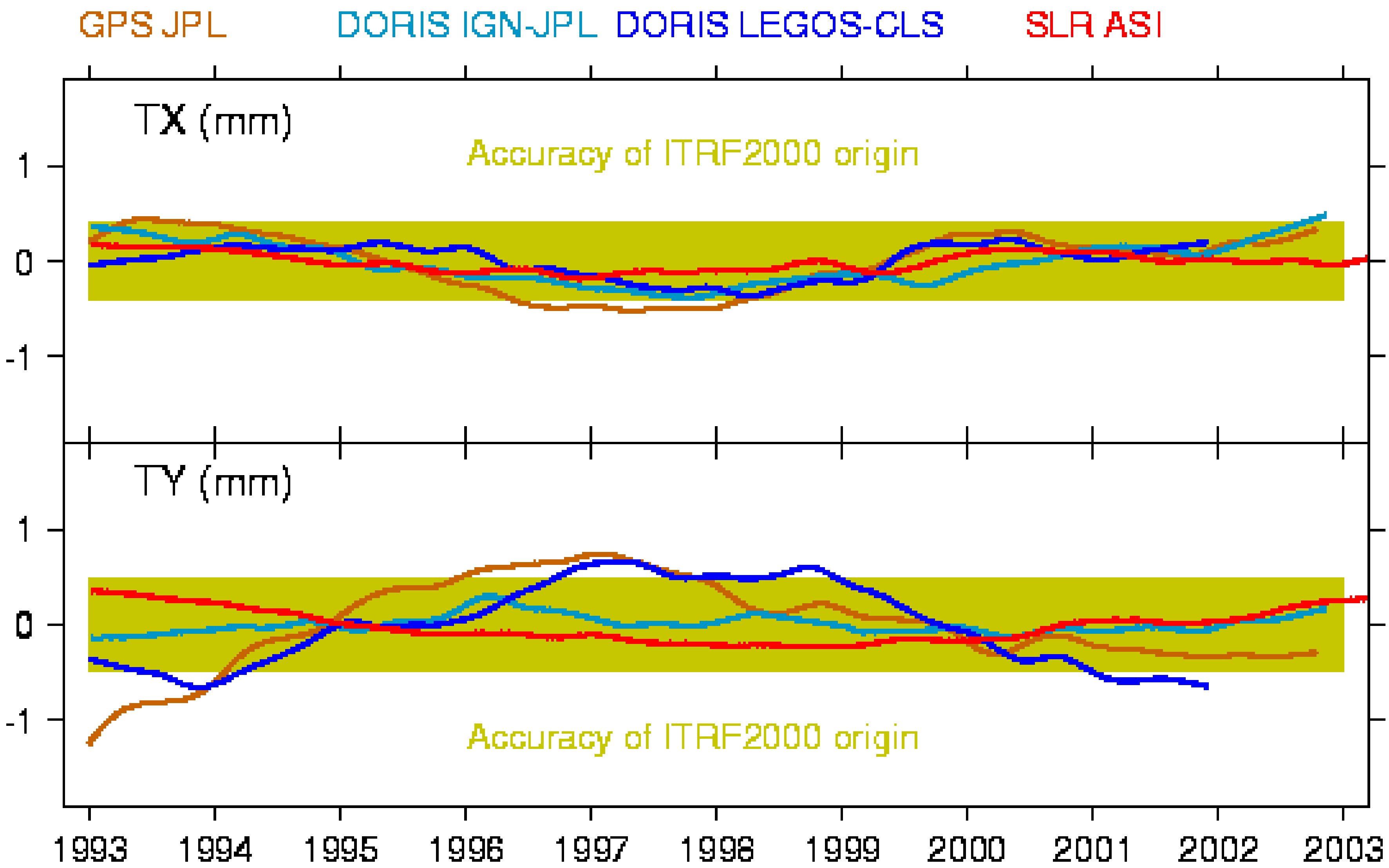
Amplitudes

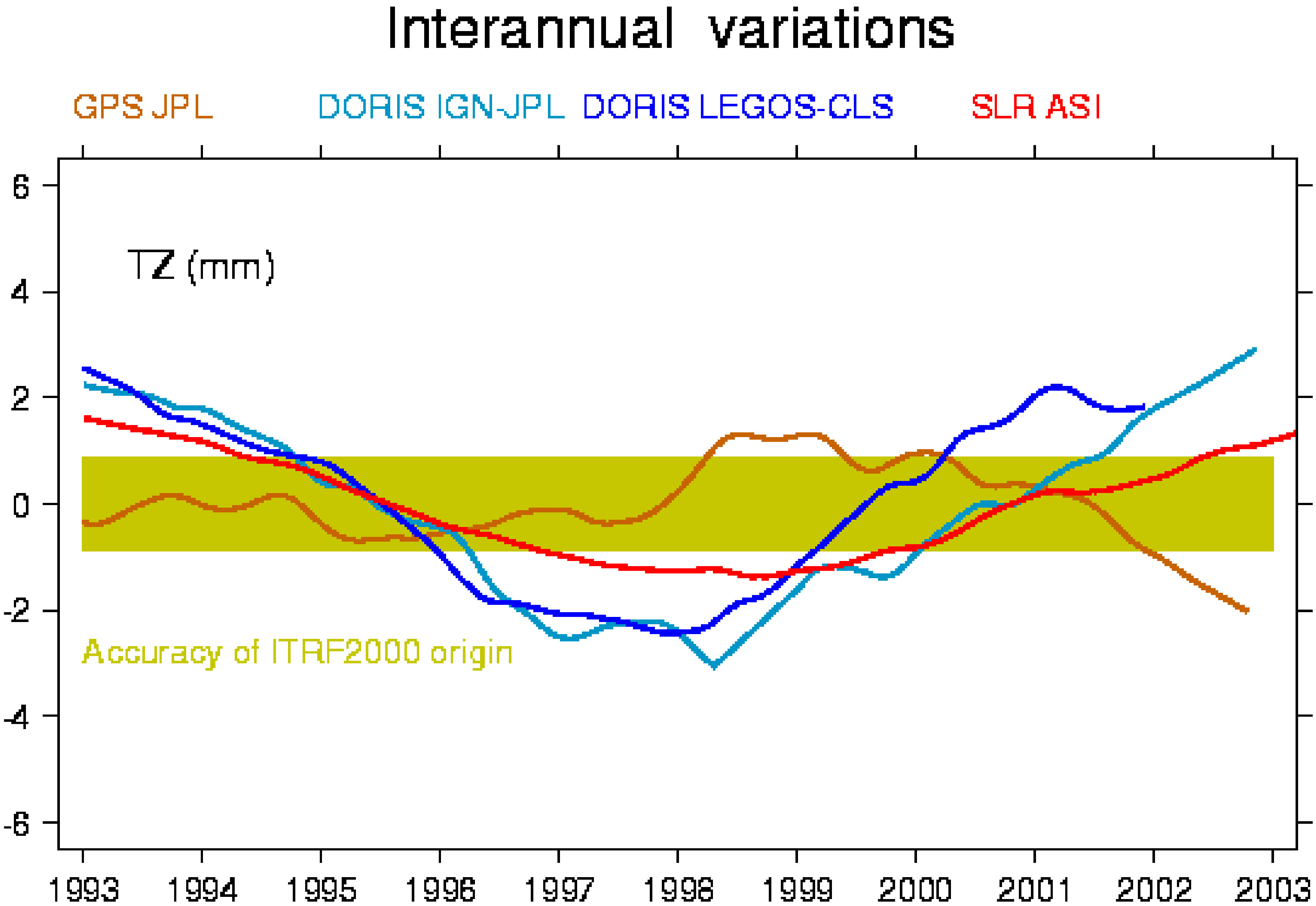
Doris IGN-JPL and **GPS** seasonal amplitudes vary with time.

Phases

Various agreements/disagreements between series.
This suggests the presence of seasonal systematic errors.

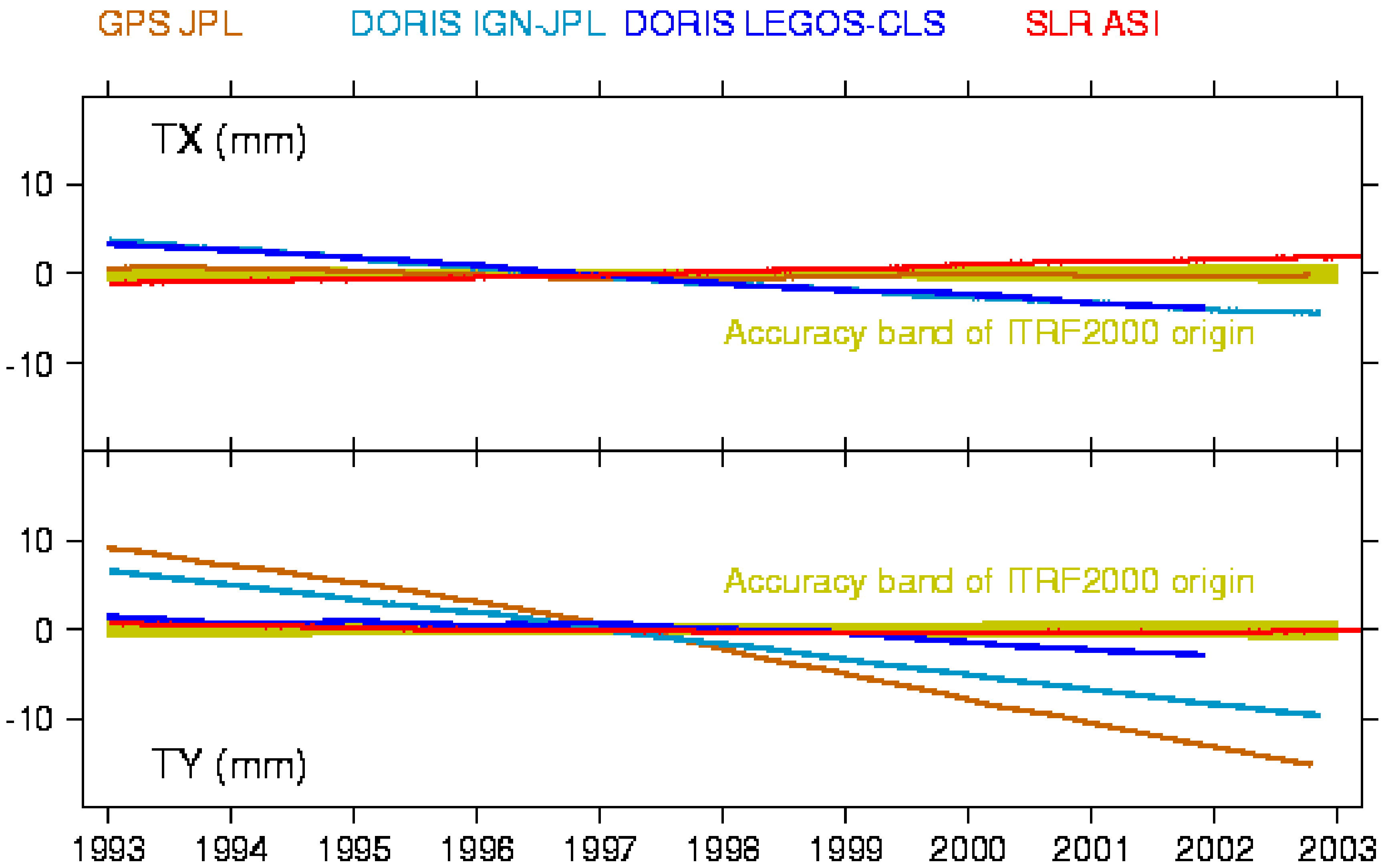
Interannual variations



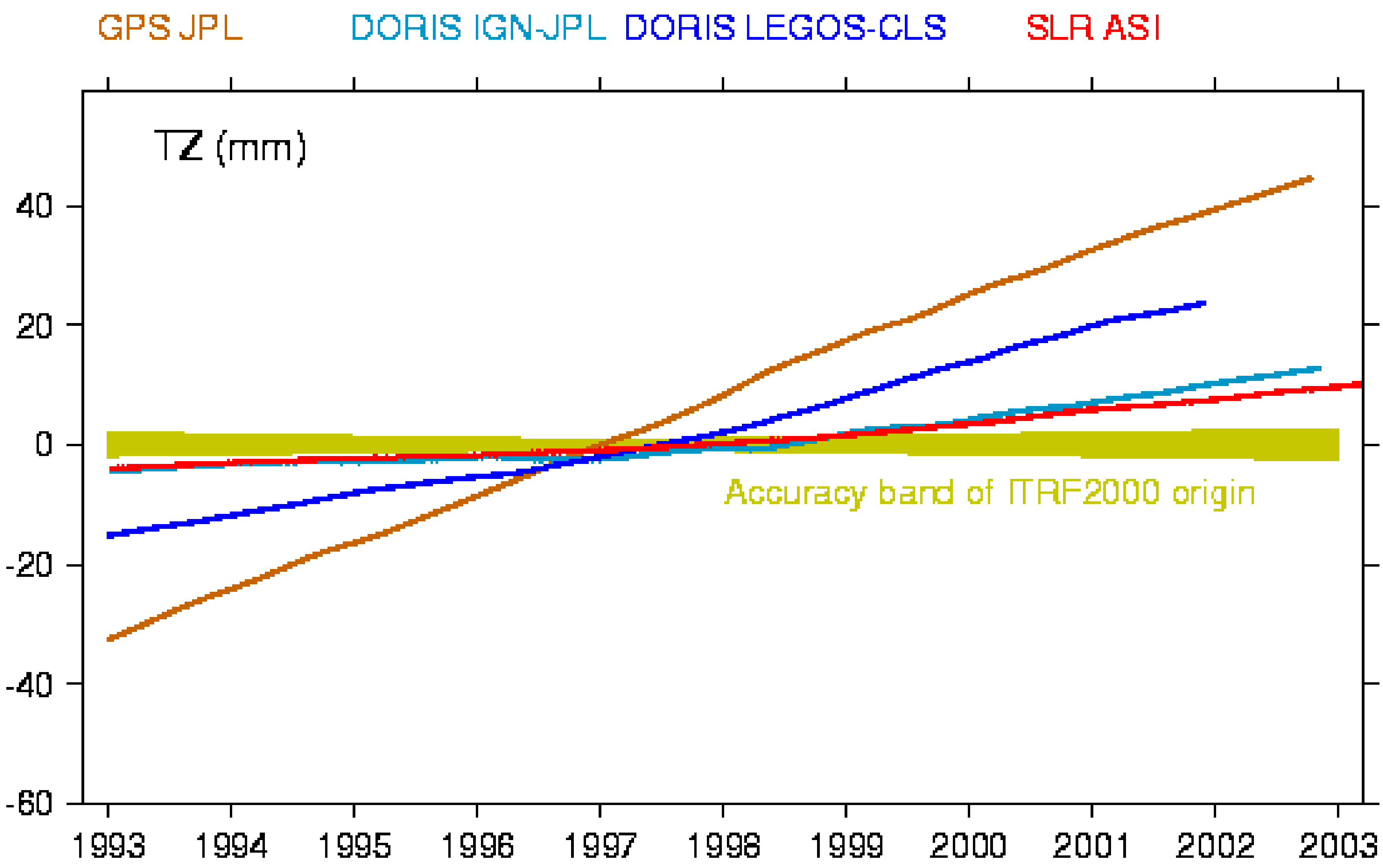


Interannual variations
GPS JPL
DORIS IGN-JPL
DORIS LEGOS-CLS
SLR ASI
TZ (mm)
Accuracy of ITRF2000 origin
6
4
2
0
-2
-4
-6
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003

Low frequency variations (> ~ 5 years)



Low frequency variations (> ~ 5 years)



Interannual and low frequency variations

Interannual frequency band

Possible long periodic variations. Amplitudes are up to

2 mm peak-to-peak in Tx, Ty,

5 mm peak-to-peak in Tz.

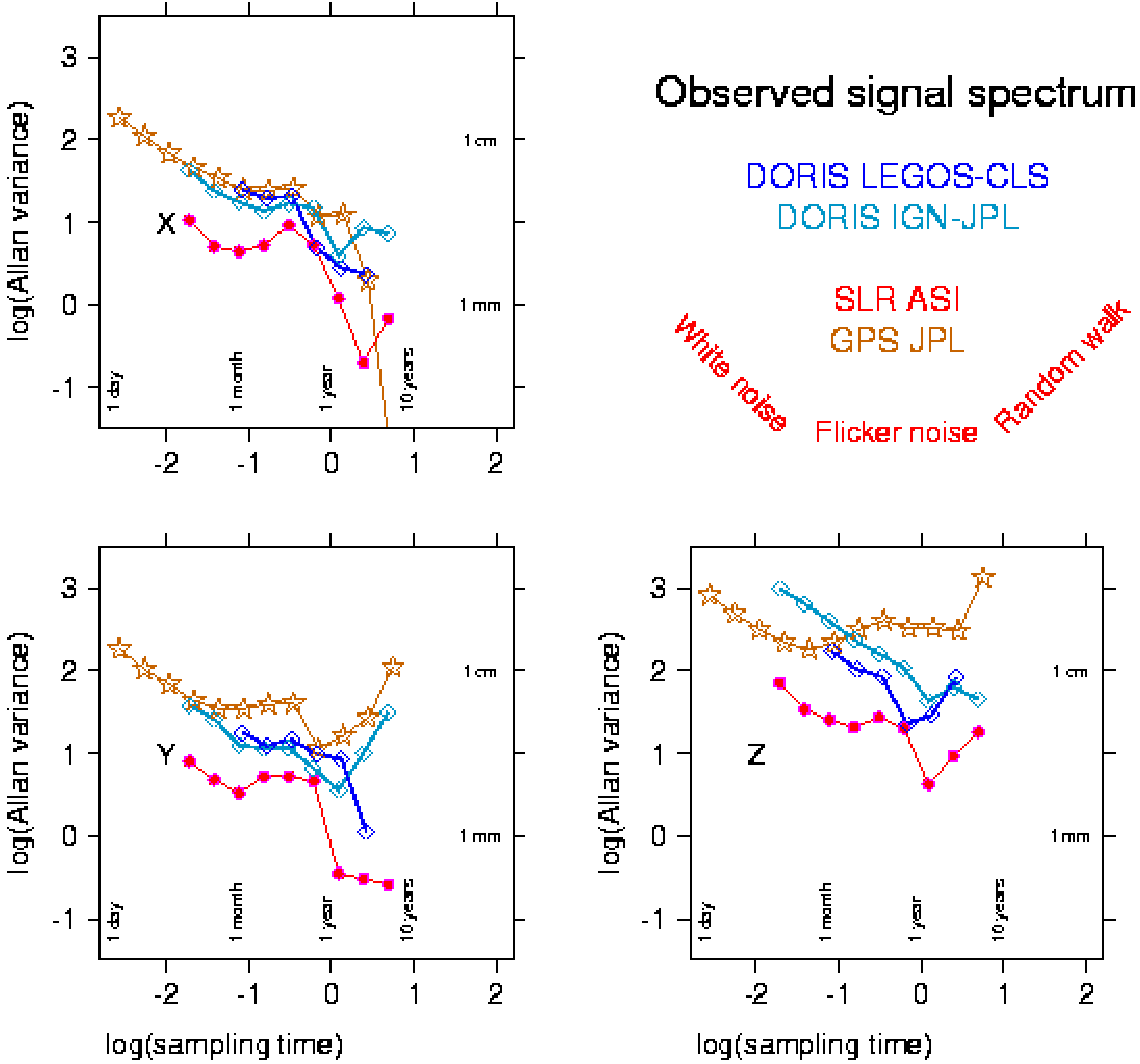
Similar amplitude and phase in the TZ signals of **SLR** and **Doris**.

Long term

Quasi linear trends relative to ITRF2000 differ from technique to technique: up to

3 mm/year in Tx, Ty,

7 mm/year in Tz.


Observed signal spectrum
DORIS LEGOS-CLS
DORIS IGN-JPL
SLR ASI
GPS JPL
White noise
Flicker noise
Random walk
X
Y
Z
log(Allan variance)
log(sampling time)
1 cm
1 mm
1 day
1 month
1 year
10 years
3
2
1
0
-1
-2

Observed non seasonal signal spectrum

Roughly common spectral features

1- 30 days: ***white noise***

1-12 months: ***flicker noise***

Long term: The presence of ***random walk*** suggests that the observed drifts are stochastic. May be related to instability of the underlying reference frame.

Stability Levels in mm

Sampling times

	SLR	Doris	GPS	SLR	Doris	GPS	SLR	Doris	GPS
	----- month ------			------- year -------			----- 3-year -----		
TX:	**2.5**	**4.2**	**4.5**	**1. 3**	**1.9**	**3.6**	**0.7**	**1.9**	**3.6**
TY:	**1.8**	**3.8**	**6.0**	**0.9**	**2.8**	**3.8**	**0.5**	**2.5**	**6.3**
TZ:	**5.3**	**14.**	**14.**	**3.0**	**6.3**	**20.**	**3.6**	**8.9**	**25.**

Conclusion: more questions than answers!

- Analysis modelling and strategies

- *What other phenomena could mimic seasonal geocenter motion?*
- *Correlated interannual variations (6 mm peak to peak in Tz) to be investigated*
- *Investigate long term stochastic instabilities*

- Need for

- *Conceptual definition of Tx, Ty, Tx*
- *Standard exchange format*