Datum definition within and accross techniques: station weight factors reflecting their long term stability

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A definition of station stability based on time series analysis

1. Principal Component Analysis

- Consider the observed
  residual motions after taking out a 3D linear drift
- Perform Principal Component Analysis (PCA)
  in the time domain on the 3D series of residuals. The first principal component (**PCT_1**) explains most of the variance. It is studied as
  - seasonal
  - stochastic

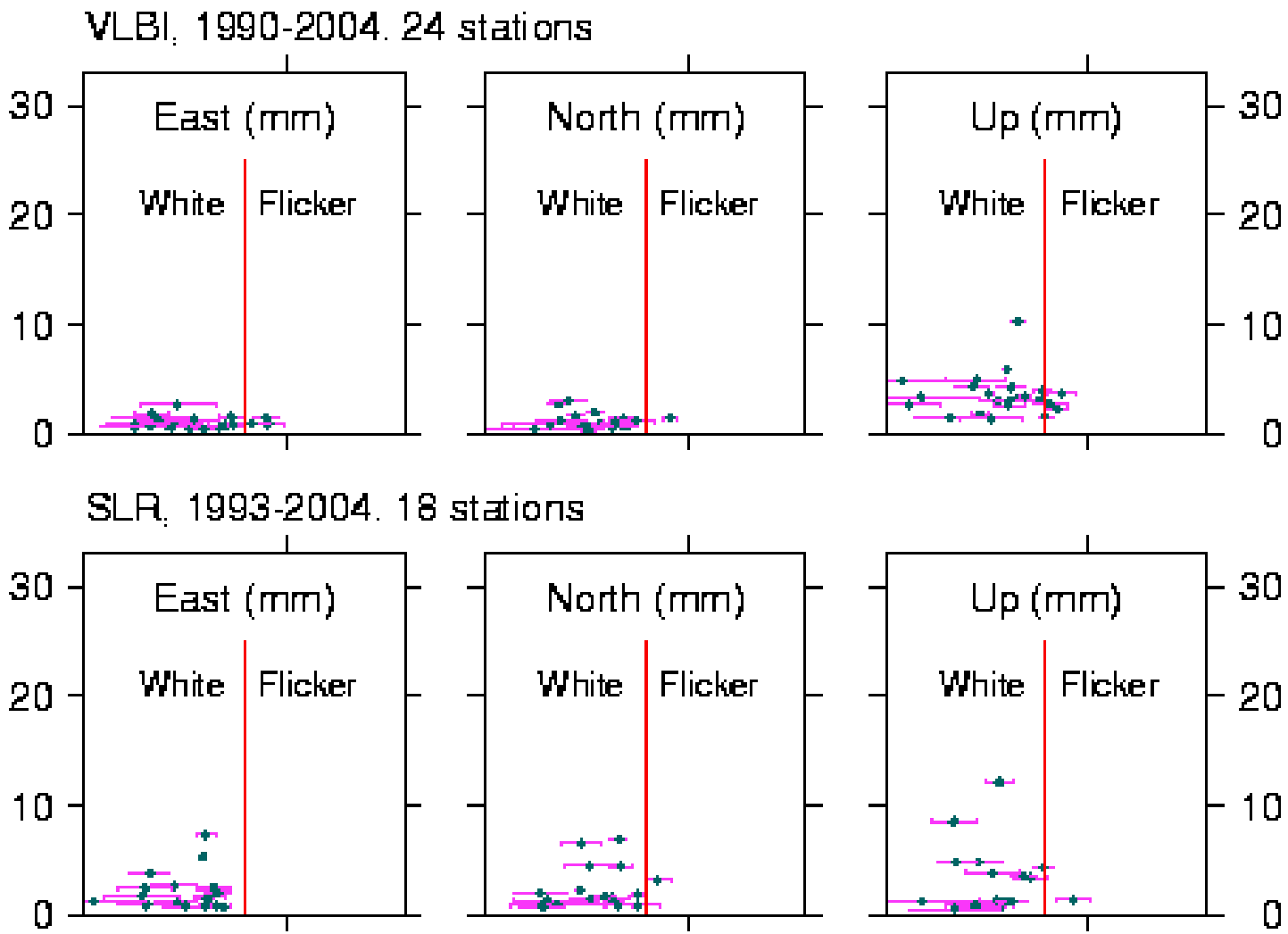
A definition of station stability based on time series analysis

2. Allan variance Analysis

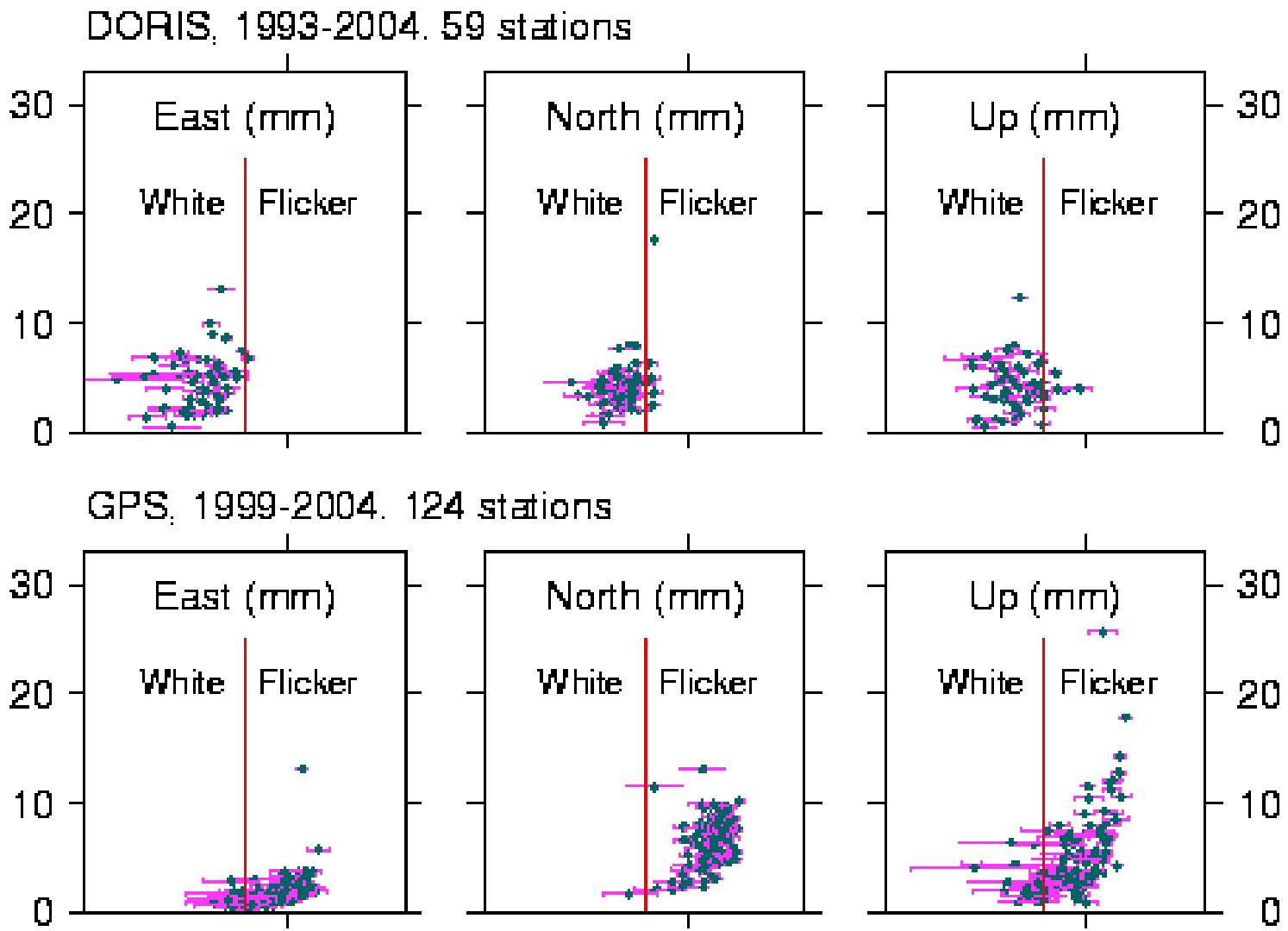
- Implement the Allan variance method for
  - Describing the residual **signal spectrum**
  - Measuring the **stability**
- **Weighting factor**: ratio of the **Allan standard deviation** for a given sampling interval wrt the **equivalent formal errors** of the data
- Two sampling intervals considered here
  - **One year - insensitive to annual signatures**
  - Original or near to it (**one week**, other)

  Four years feasible only for time series longer than 10 years

Stability and extra linear spectral signature VLBI & SLR



Stability and extra linear spectral signature DORIS, GPS



Comments on the analysis methods

- **PCA** based on the **3D "cross-covariance" of the time series** of residual coordinates. The first PCT represents the 3D most significant time behaviour of the series

- Characterization of the **signal spectrum by the Allan variance** uses the relationship between the Allan variance and the data sampling interval (Allan graph):
  - White noise – spectral density independent of frequency f => noise level improved for longer time spans
  - Flicker noise – spectral density ~1/f => noise level not improved for longer time spans
  - Random walk (spectral density ~$1/f^2$) not encountered <= filtered out by the 3D linear trend.

Long term stability (series longer than 10 years)

- **Spectrum and 4-year Allan standard deviation of the Principal Component in the time domain**

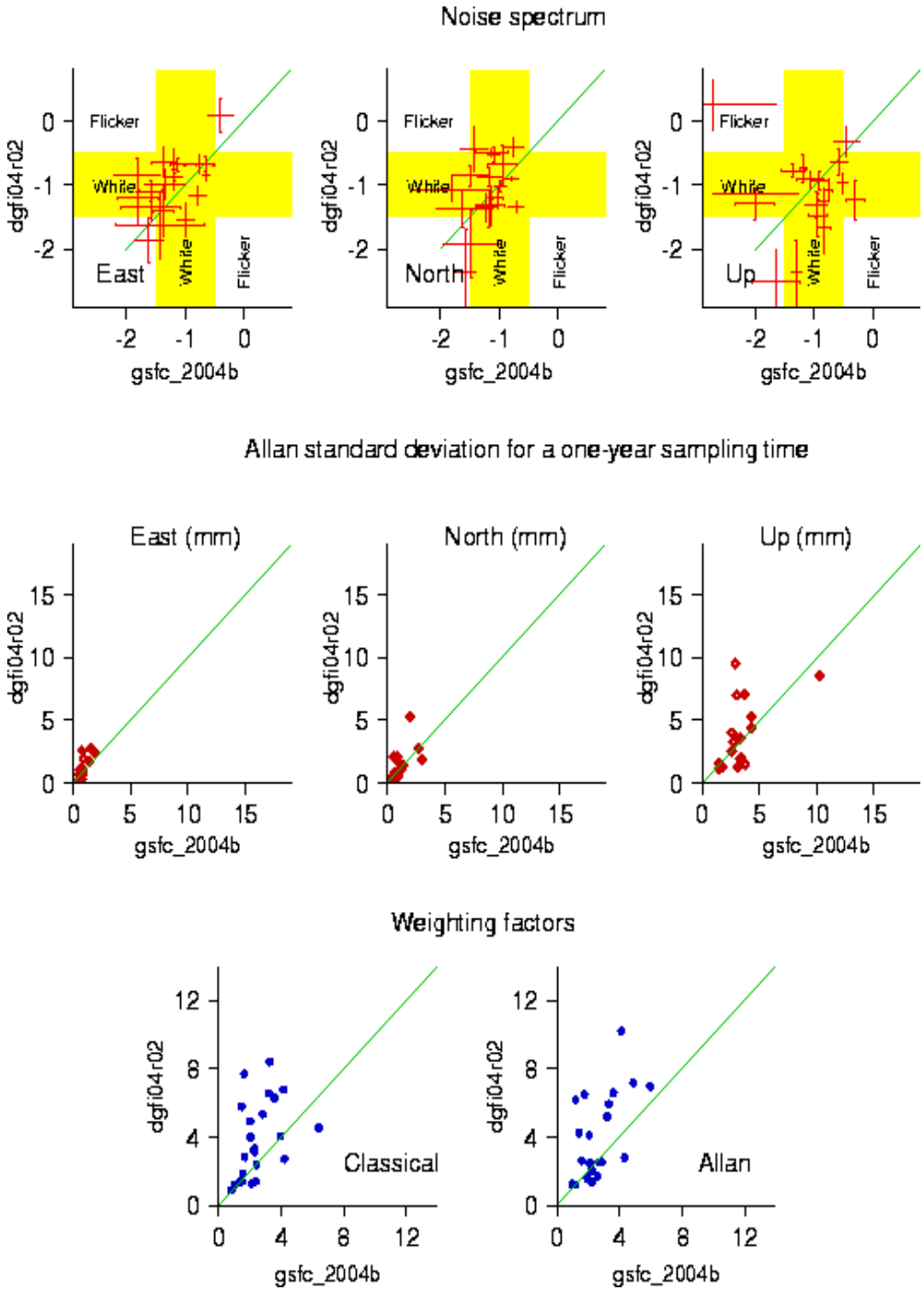
Tech.	Nb of stations considered	White noise Nb sta	White noise expl. var	White noise Allan StDv	Flicker noise Nb sta	Flicker noise expl. var	Flicker noise Allan StDv
VLBI	14	14	78%	1.2 mm			
GPS	30	9	74%	1.7 mm	21	81%	6.4 mm
DORIS	12	12	58%	3.7 mm			
SLR	9	9	64%	3.9 mm			

Two VLBI solutions:

GSFC & DGFI

1-yr stability

Weight factors

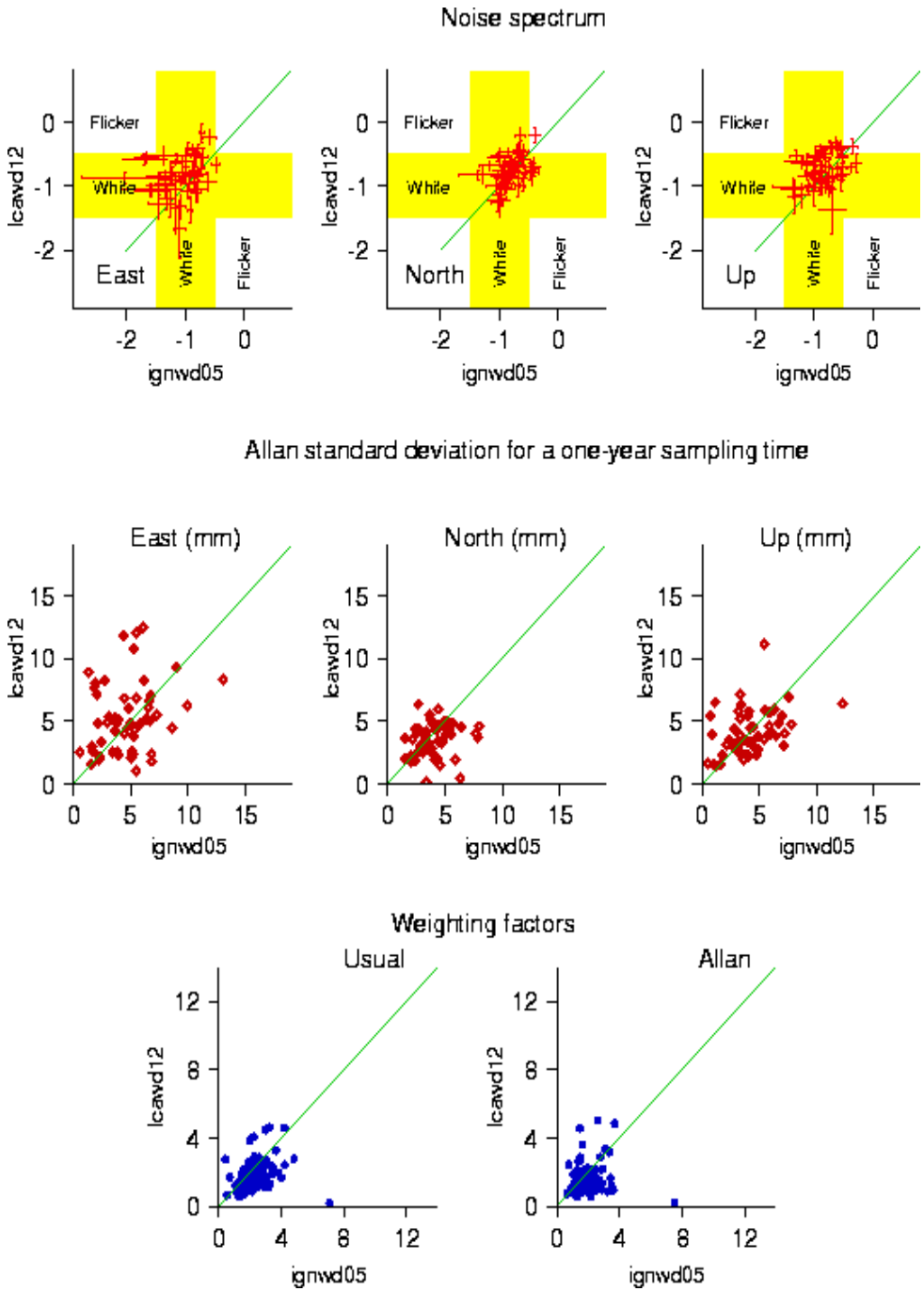


Two DORIS solutions:

IGN-JPL & LEGOS-CLS

1-yr stability

Weight factors

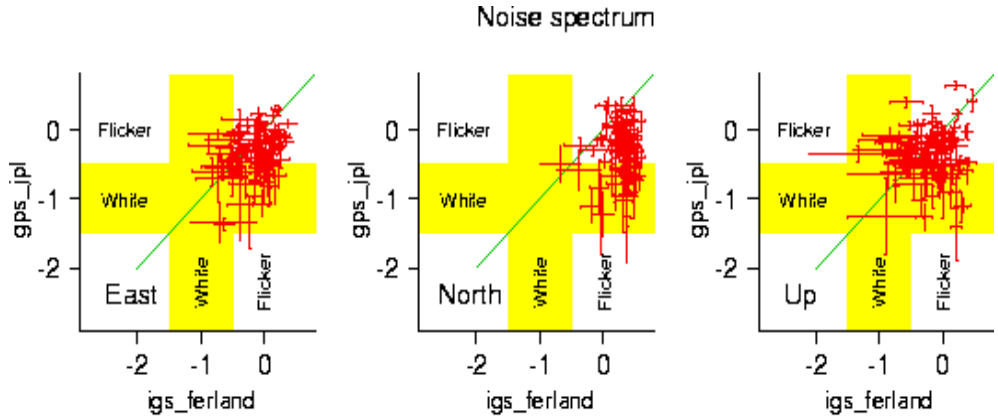


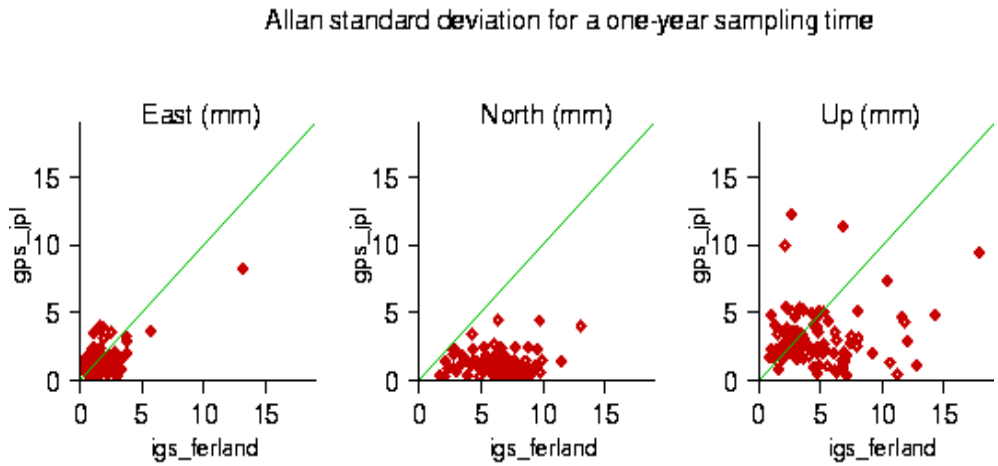
Two GPS solutions:

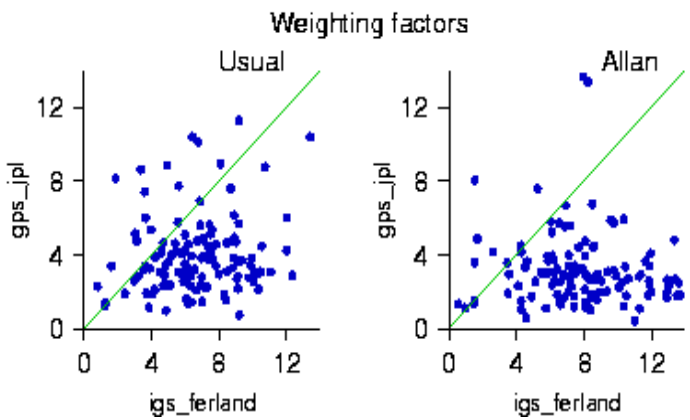
IGS & JPL

1-yr stability

Weight factors



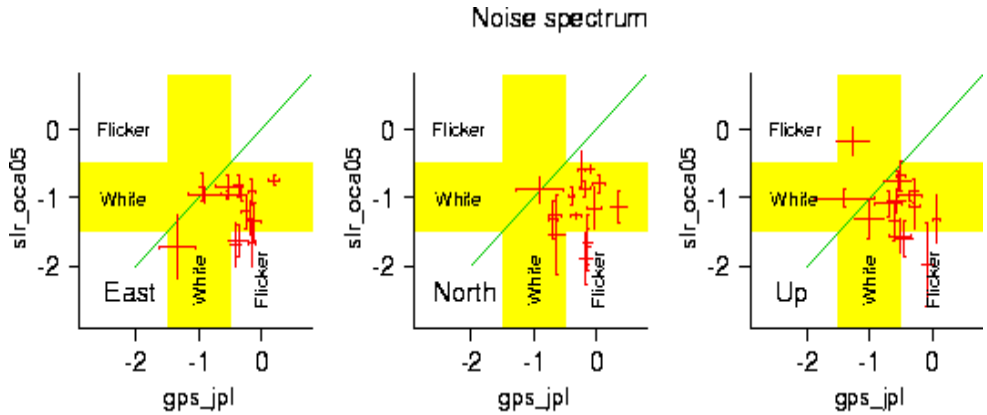


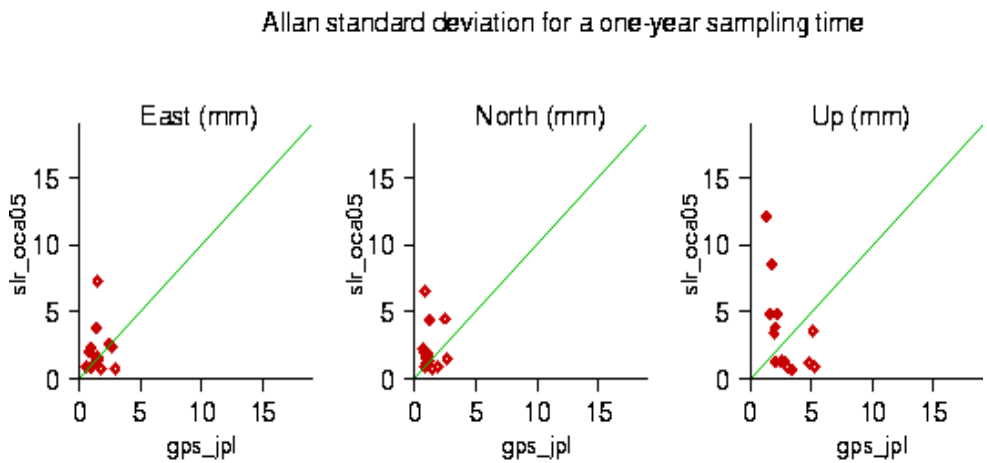


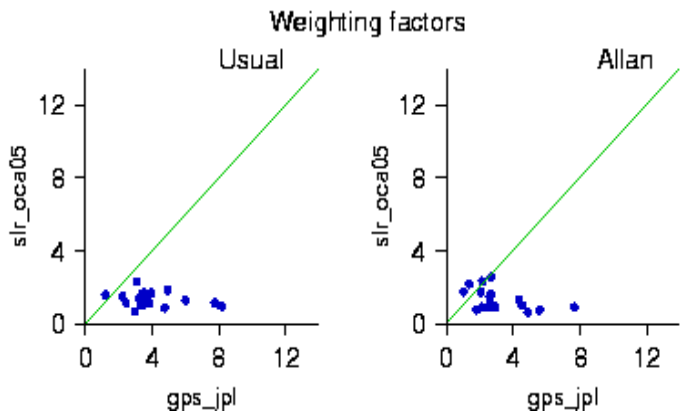
GPS & SLR

1-yr stability

Weight factors



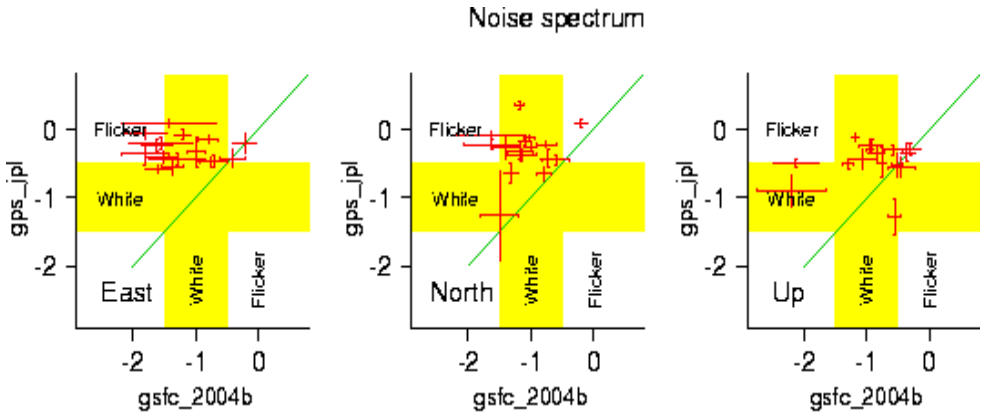


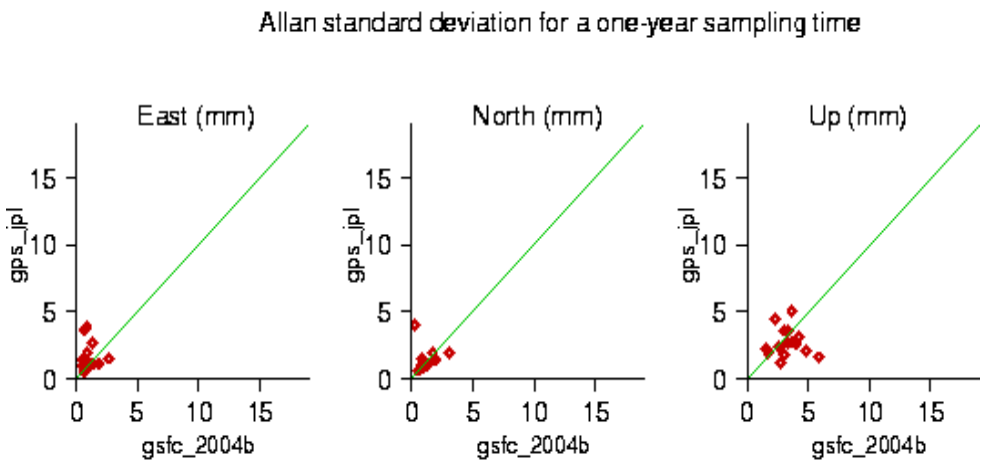


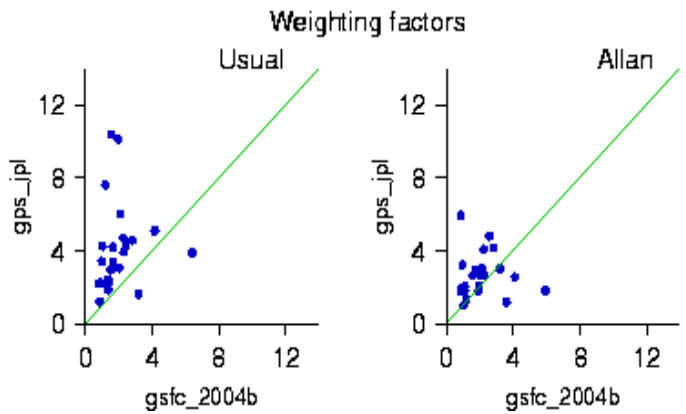
VLBI & GPS

1-yr stability

Weight factors







A quick glance at the stability of VLBI and GPS **polar motion series (**Three-cornered hat method)

Allan standard deviation (μas)

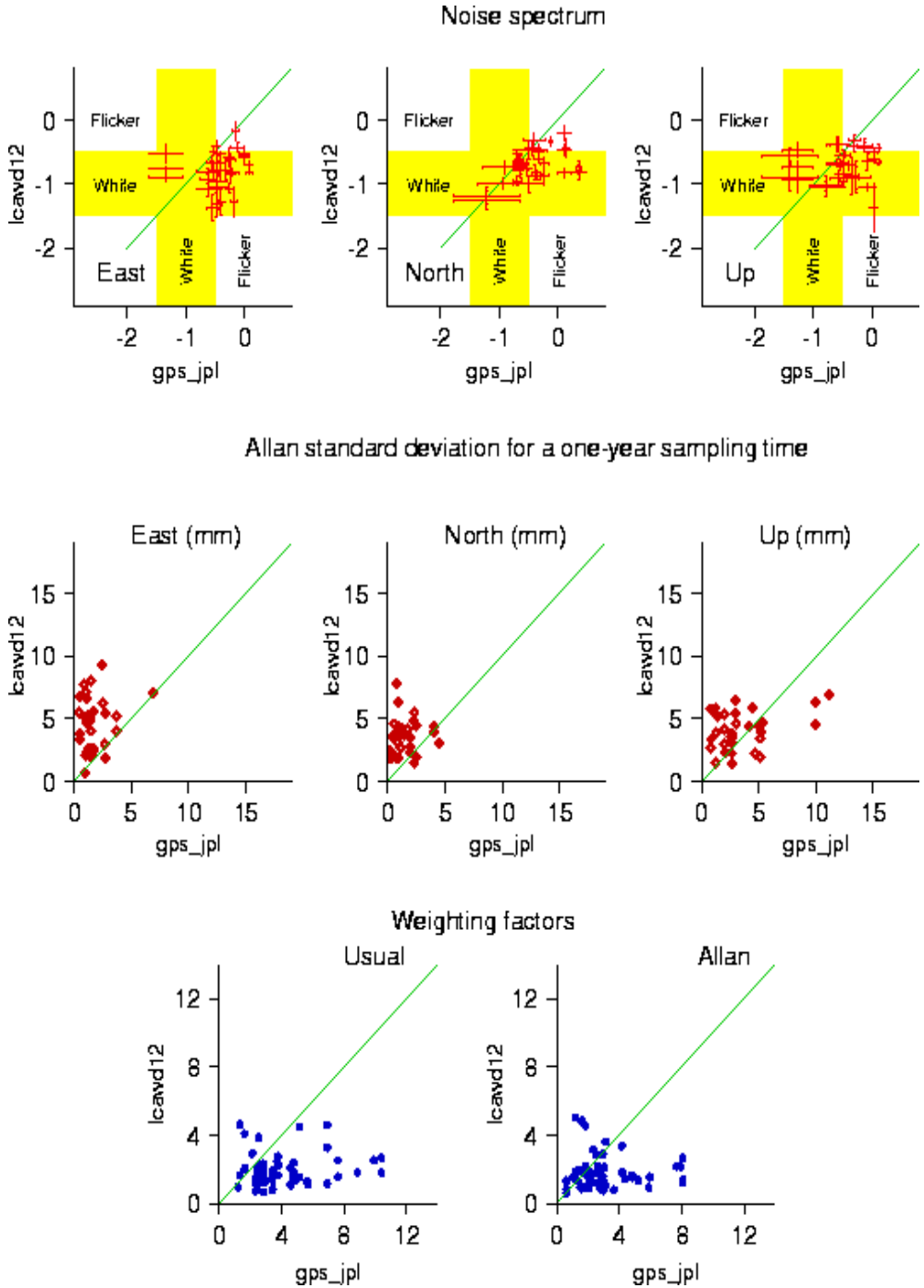
(corresponding weight factor)

	--------- x ---------		--------- y ---------	
Technique	7d	112d	7d	112d
VLBI	56 (1.3)	20 (0.5)	56 (1.4)	19 (0.5)
GPS	54 (3.6)	50 (3.4)	37 (3.5)	26 (1.7)

GPS & DORIS

1-yr stability

Weight factors



Summary

- Spectrum of the Principal Component in the non-linear station motion :
  - **VLBI, SLR, DORIS: 100% White noise**
  - **GPS: 1/3 White noise, 2/3 Flicker noise**
- One-year weight factors according to station:
  - **SLR ~1 => ~ 3**
  - **DORIS ~1 => ~ 5**
  - **VLBI ~1 => ~ 8**
  - **GPS ~1 => ~ 15**
- In our opinion, weighting in reference frame definition should take into account:
  - **Stations individually**
  - **Long term stability**