Impact of loading effects on the Terrestrial Reference Frame determination

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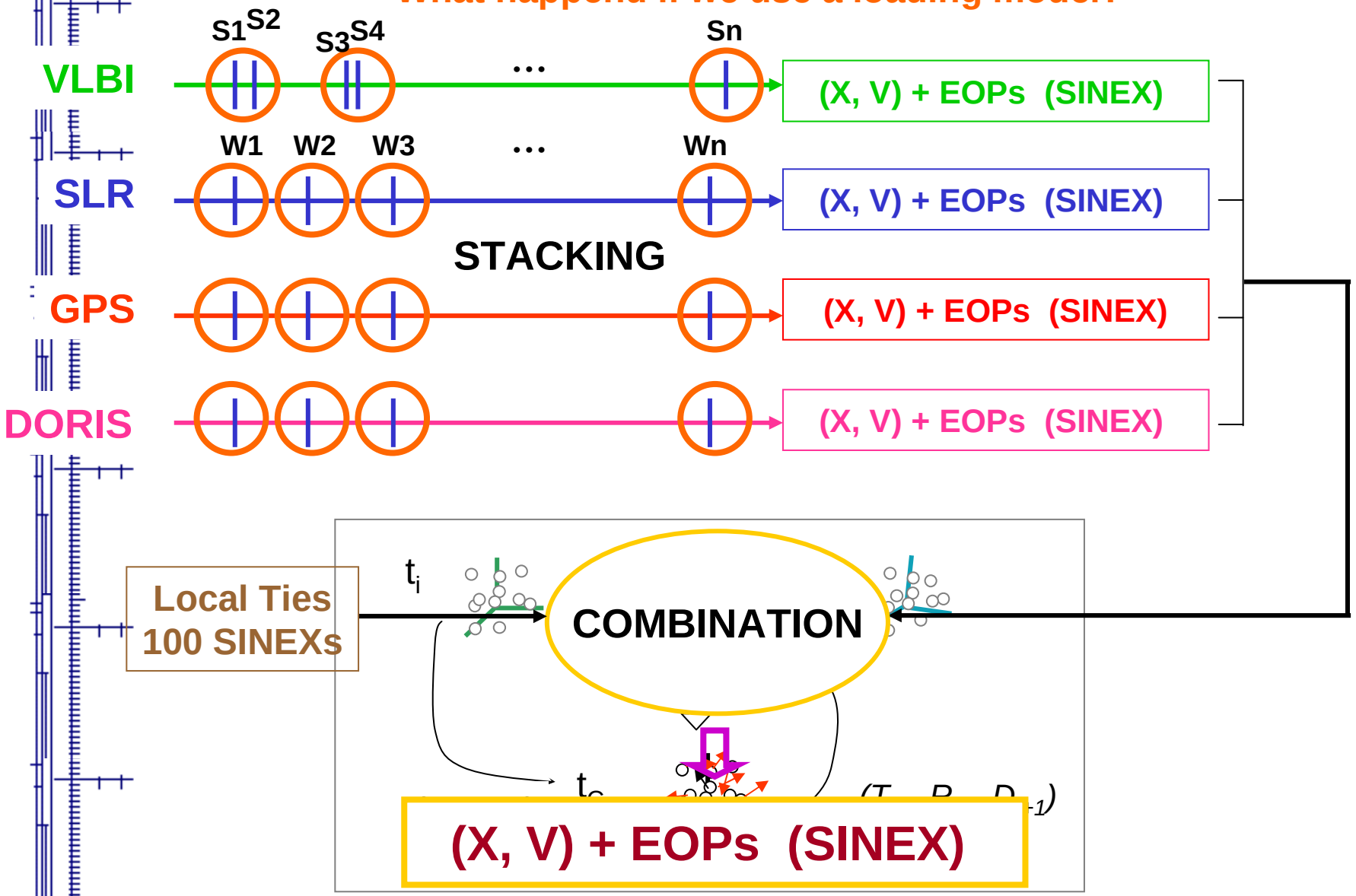
ITRF2005 computation strategy

What happend if we use a loading model?



Classification of IERS models

IERS conventions

$$X(t) = X_R(t) + \Sigma\, \Delta X_i(t)$$

where $\Delta X_i(t)$ are "regularization corrections" to remove mostly high-frequency (geophysical) variations

*According to Ray et al. Position paper presented at the IERS Workshop on Conventions, BIPM, September 2007 **

Class 1 model - reduction

Class 2 model - conventional

Class 3 model - useful

– **solid Earth (body) tide (no change)**
– **ocean tidal loading (text clarified)**
– **solid Earth pole tide (no change)**
and
– **ocean pole tide loading (recent update), including long periods**
– **S1/S2 atmospheric pressure tidal loading (under evaluation)**

Non tidal displacement model

*http://www.bipm.org/en/events/iers/iers_documents.html

Why using a loading model to estimate a secular frame?

1) Should reduce station position time series scattering
2) Reduce the network effect

A Posteriori corrections

$$\hat{X}^i(t) + \bar{X}^i_{load}(t) = T(t) + (R(t) + (1 + \lambda(t)) \cdot I_3) \cdot [X^i_{ITRF}(t_0) + X^i_{ITRF}(t - t_0)] + \delta^i_{stat}$$

$$\Longleftrightarrow$$

$$\hat{X}^i(t) = T(t) + (R(t) + (1 + \lambda(t)) \cdot I_3) \cdot [X^i_{ITRF}(t_0) + X^i_{ITRF}(t - t_0) + \bar{X}^i_{load}] + \delta^i_{stat}$$

more similar shape

A Priori corrections

$$\hat{X}^i(t) = T(t) + (R(t) + (1 + \lambda(t)) \cdot I_3) \cdot [X^i_{ITRF}(t_0) + X^i_{ITRF}(t - t_0)] + \delta^i_{stat}$$

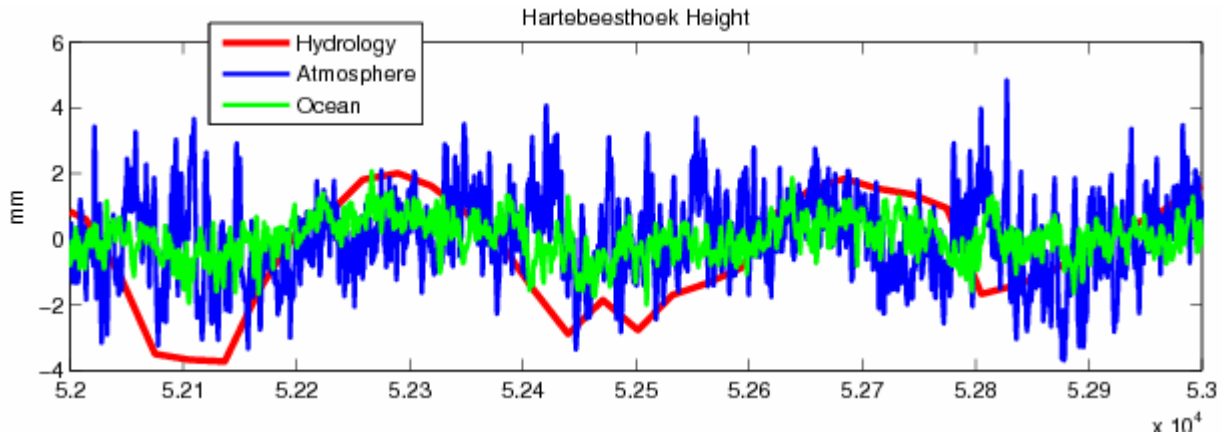
more similar shape + aliasing effect reduction?

Loading model

Green's function approach.

- 6 hour atmospheric loading displacement time series (NCEP)
- 12 hour ocean non tidal loading (ECCO)
- 1 month hydrological loading (LaD)

Loading model has been detrended over 1993.0 – 2006.0



TRF a posteriori correction : impact on the secular reference frame

(ILRS, IVS and IGS solution have been studied)

STACKED FRAME : comparison to stacked frame built without correction

Origin:

Non zero component (2σ)

SLR	T_X	:	0.23 +/- 0.05 mm	*At epoch 00:001*
	dT_X/dt	:	0.06 +/- 0.02 mm/yr	

Scale:

Atmospheric loading blue sky effect 0.18 mm on scale (Collilieux et al. 2007, Otsubo et al. 2004)

Non zero component (2σ)

SLR	λ	:	0.25 +/- 0.04 mm	*At epoch 00:001*
VLBI	λ	:	0.08 +/- 0.01 mm	*At epoch 00:001*
SLR	dλ/dt	:	0.02 +/- 0.01 mm/yr	
VLBI	dλ/dt	:	-0.06 +/- 0.01 mm/yr	

TRF a posteriori correction : network effect reduction

Residual annual signal amplitude in SLR translation and scale

	TX (mm)	TY (mm)	TZ (mm)	Scale (mm)
Before correction	**3.2 +/- 0.3**	**3.9 +/- 0.2**	**2.8 +/- 0.4**	**1.7 +/- 0.2**
After correction	**0.6 +/- 0.2**	**2.1 +/- 0.2**	**2.4 +/- 0.2**	**0.8 +/- 0.2**

Residual annual signal in VLBI scale

	VLBI scale (mm, deg)	Annual thermal scale model
Before correction	**(1.7 +/- 0.2, 227+/-7)**	**(1.3 +/- 0.1, 194+/-1)**
After correction	**(1.0 +/- 0.2, 161+/-11)**	

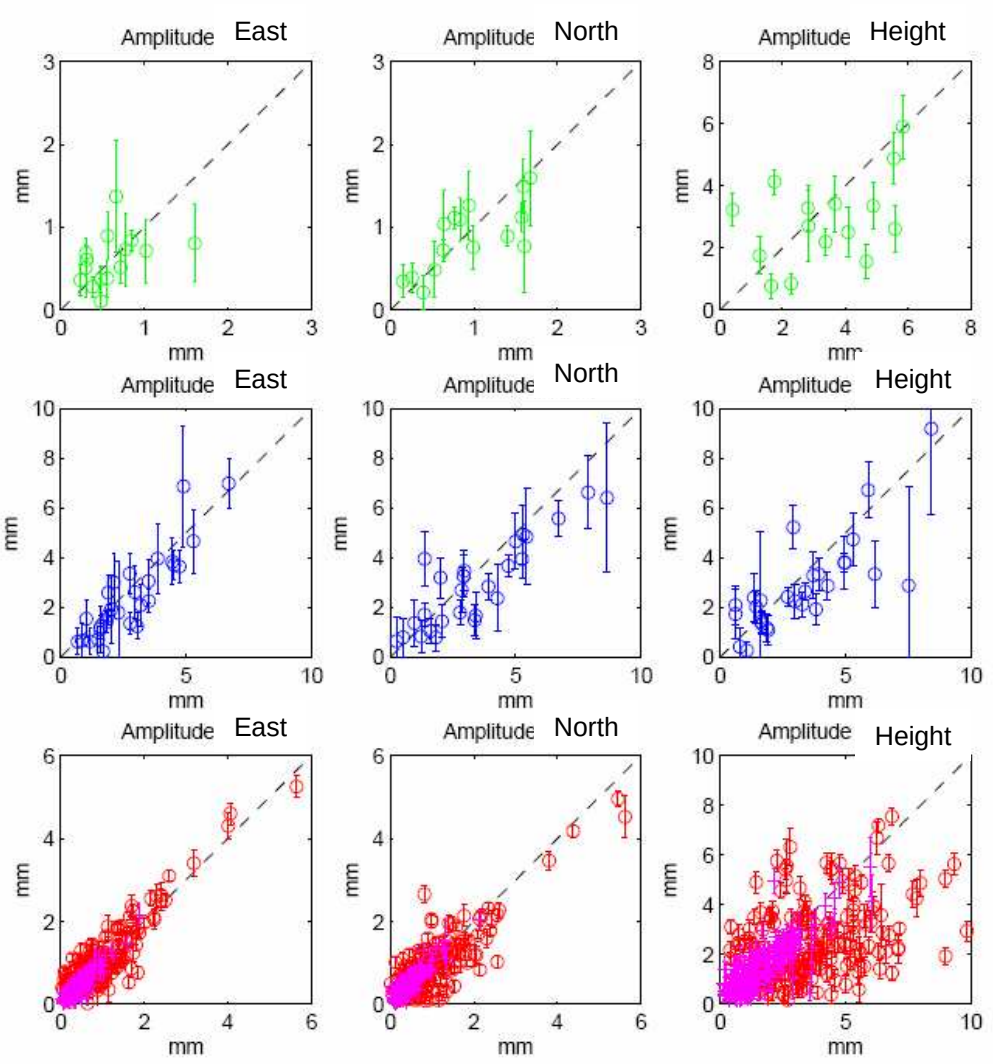
**** In red, residual annual signal greater than 1.0 mm***

TRF a posteriori correction : station position residual annual signal

VLBI

SLR

GPS



Scale not estimated

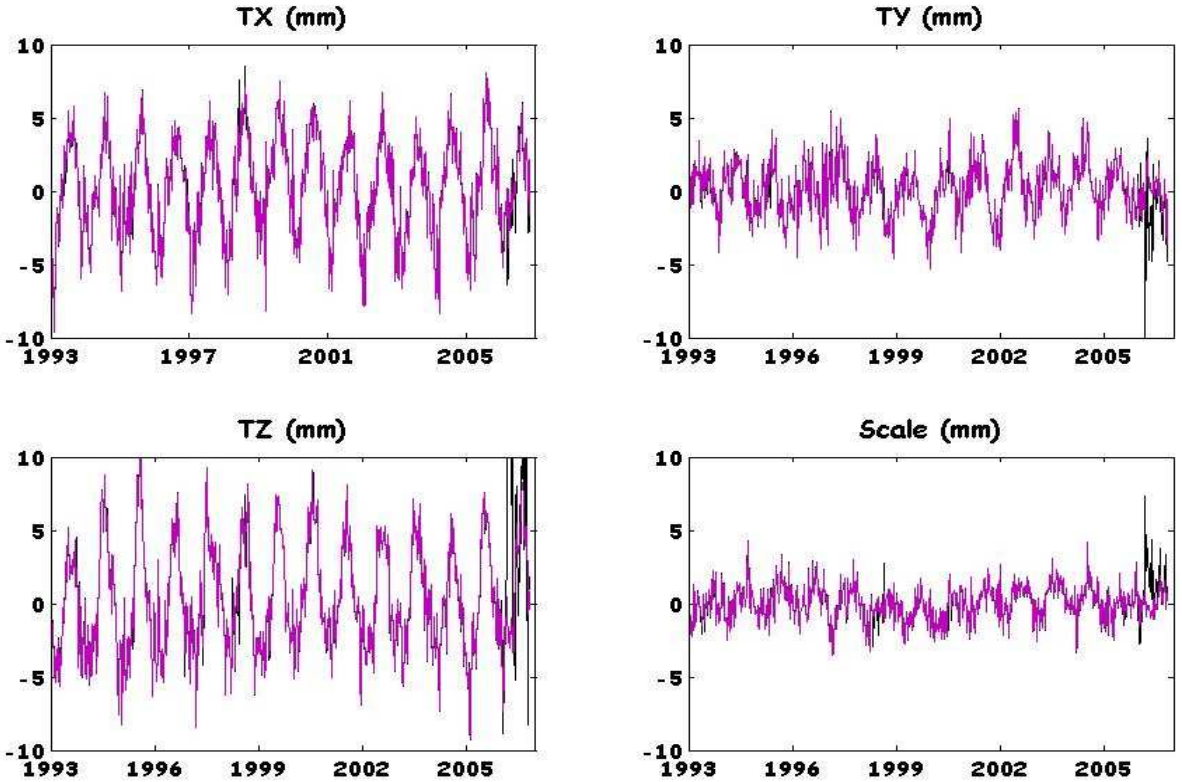
Scale estimated with a well distributed sub-network

TRF a priori correction : case of SLR (1/2)

First experiment : use of the loading model as a priori. Orbit not recomputed but empirical orbital parameter estimated

Difference WL.-WOL.

Simulations

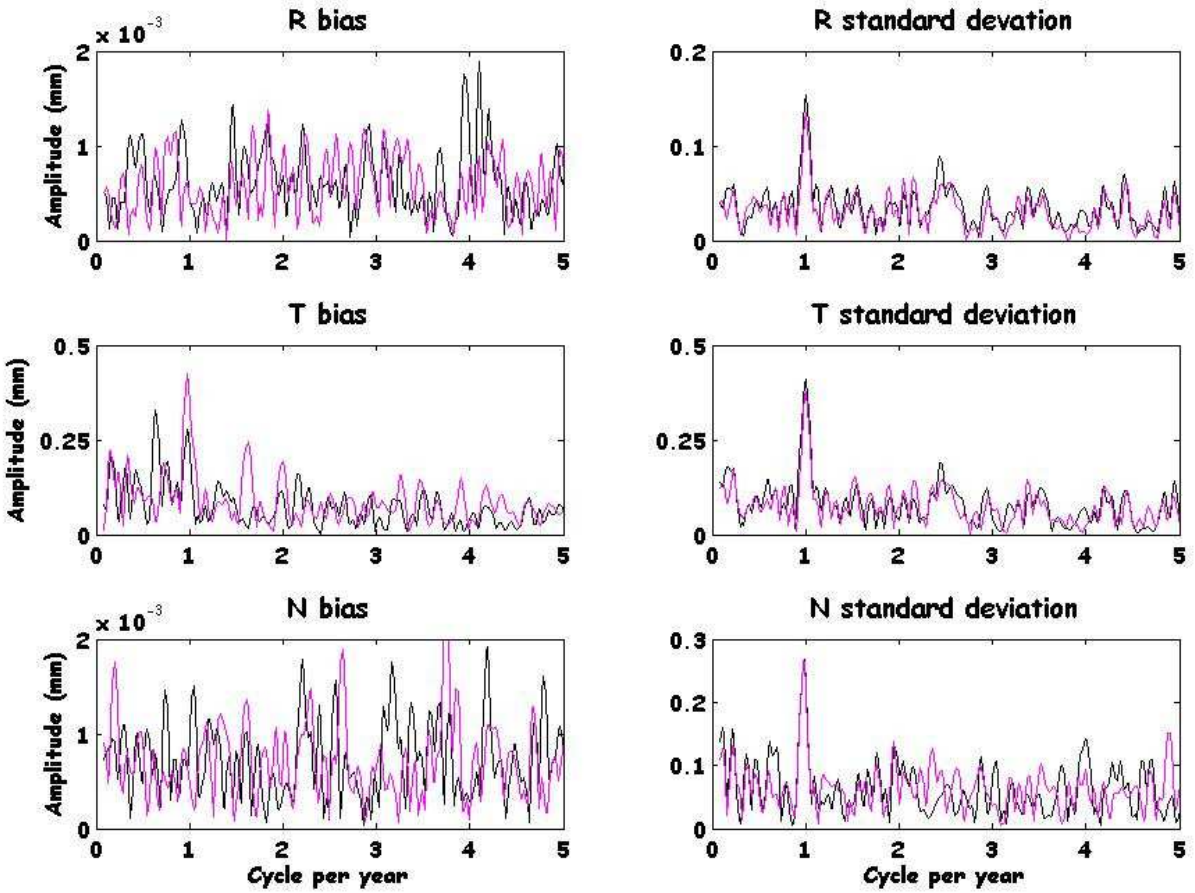


Preliminary results

Higher reduction in TZ annual signal in the a priori reduction. About **0.6 mm** (reduction of 4.3 mm vs 3.7)

TRF a priori correction : case of SLR (2/2)

Possible interaction with orbital parameters: results on synthetic data



LAGEOS-1

LAGEOS-2

Conclusion

Using a loading model :

- reduces SLR translation annual signals
- reduces network effect
- produces regularized coordinates consistent with the loading model

Future work

- Apply mass conservation constraint on the loading model
- Use gravity field model consistent with the loading correction in order to compute the SLR orbits
- Validate estimated velocity field after correction by:
  - Estimating tectonic plate Euler poles
  - Compare height velocity field with GIA models

THANK YOU!!