T2L2/Jason-2: how to improve IDS products:

1)Radiation & temperature effects on DORIS USOs: a frequency model for Jason-2 and -3
2)Time bias /SLR stations: used for POD and DORIS time bias estimation

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IDS AWG, May, 22-23 2017, London UK

T2L2 on Jason-2:

An opportunity to study radiation effects:
Jason-1 [*Willis, Lemoine&Capdeville***], SPOT-5 [***Stepanek***], and Jason-2 [***Belli, Willis***]**
Jason-3: [*Belli, La Rochelle***]**

CNES [*Cibiel et al.***]:**
The sensitivity to radiation of the DORIS frequency observed in orbit is function of the quartz sensitivity itself but it is affected by the shielding effect of the USO body, the BDR body and the satellite body.
This sensitivity is, of course, function of the external radiation level which is related to the altitude of the orbit and may vary with the cumulated dose received

An opportunity to time synchronize the SLR stations [*Exertier, 2017***]:**
The T2L2 time transfer data from SLR stations to the satellites allowed us to compute the time differences of all SLR participating stations to the same time reference (Grasse SLR were time calibrated and its h-maser accurately monitored to *GPS time*.

It revealed TB (time bias) of hundreds of nanosec. to a few microsec. Whereas ILRS recommendations is 100 ns.

Current works

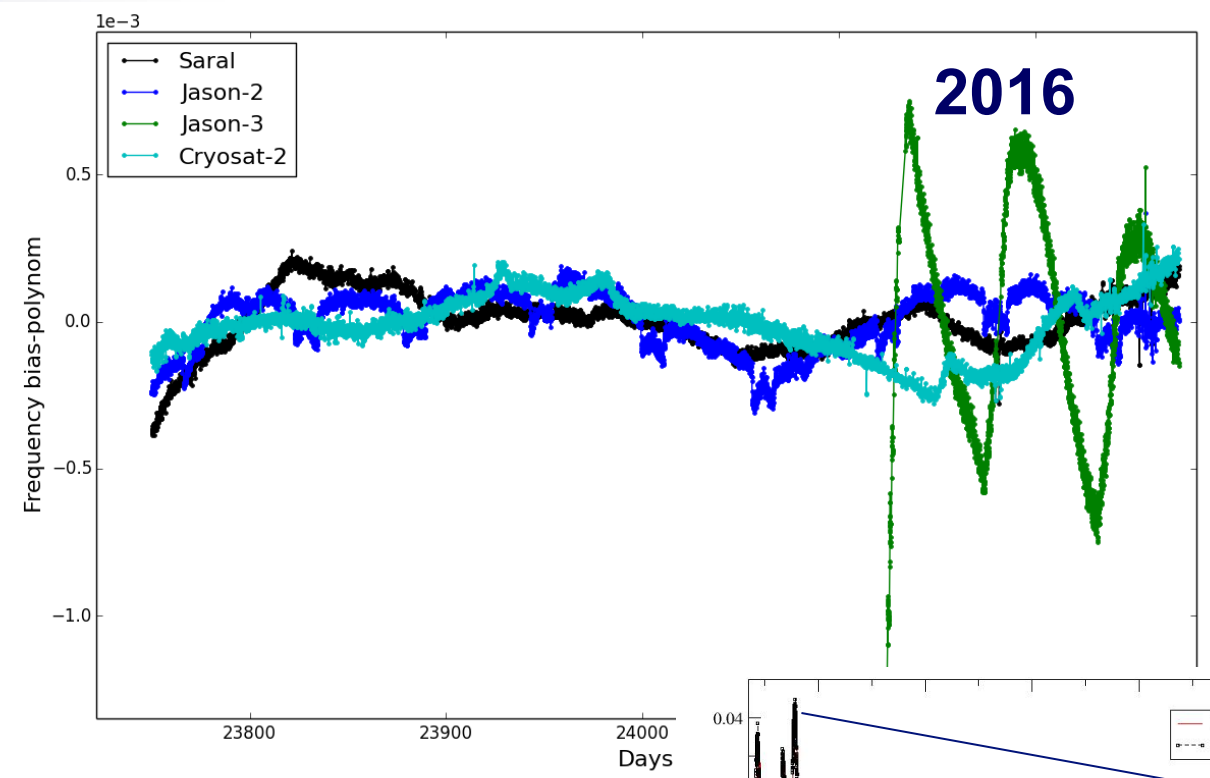
Modeling the USOs:
T2L2 /Jason-2: showed, as a time transfer space instrument (laser), a great stability to « read » the oscillator up to a few 10^{-13}
Carmen-2 /Jason-2: particle flux measurements (p+,e-) : 1 -> 300 MeV

The Jason-2 frequency model has been updated in order to correct for DORIS V2 data files
Jason-2 / Jason-3 common period (2016): an opportunity to characterize the effects of radiation on J3

SLR-time biases:
We provide ILRS-AC's with corrected (TB) time tag of each measurement (NP) for around 20 SLR stations; the goal is to confirm the impact on the station positioning (contribution of ILRS to the ITRF).

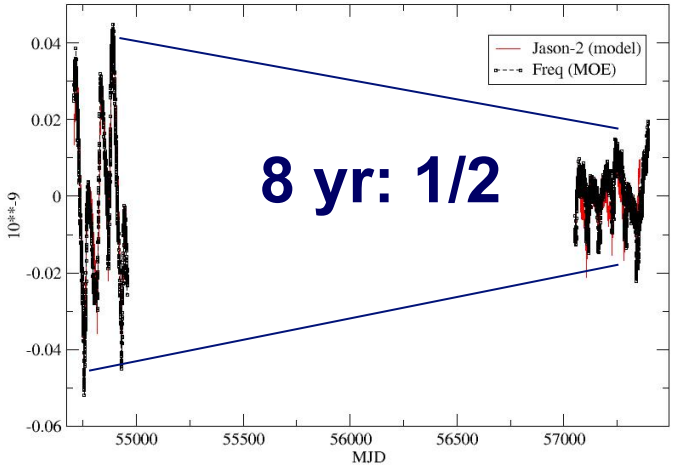
We tested the impact on SLR-T2L2 corrected data on the Jason-2 Precise Orbit Determination

DORIS USO (frequency bias): long term



Frequency variations of J3 are
>>
the ones of J2
in 2016 but not in 2008

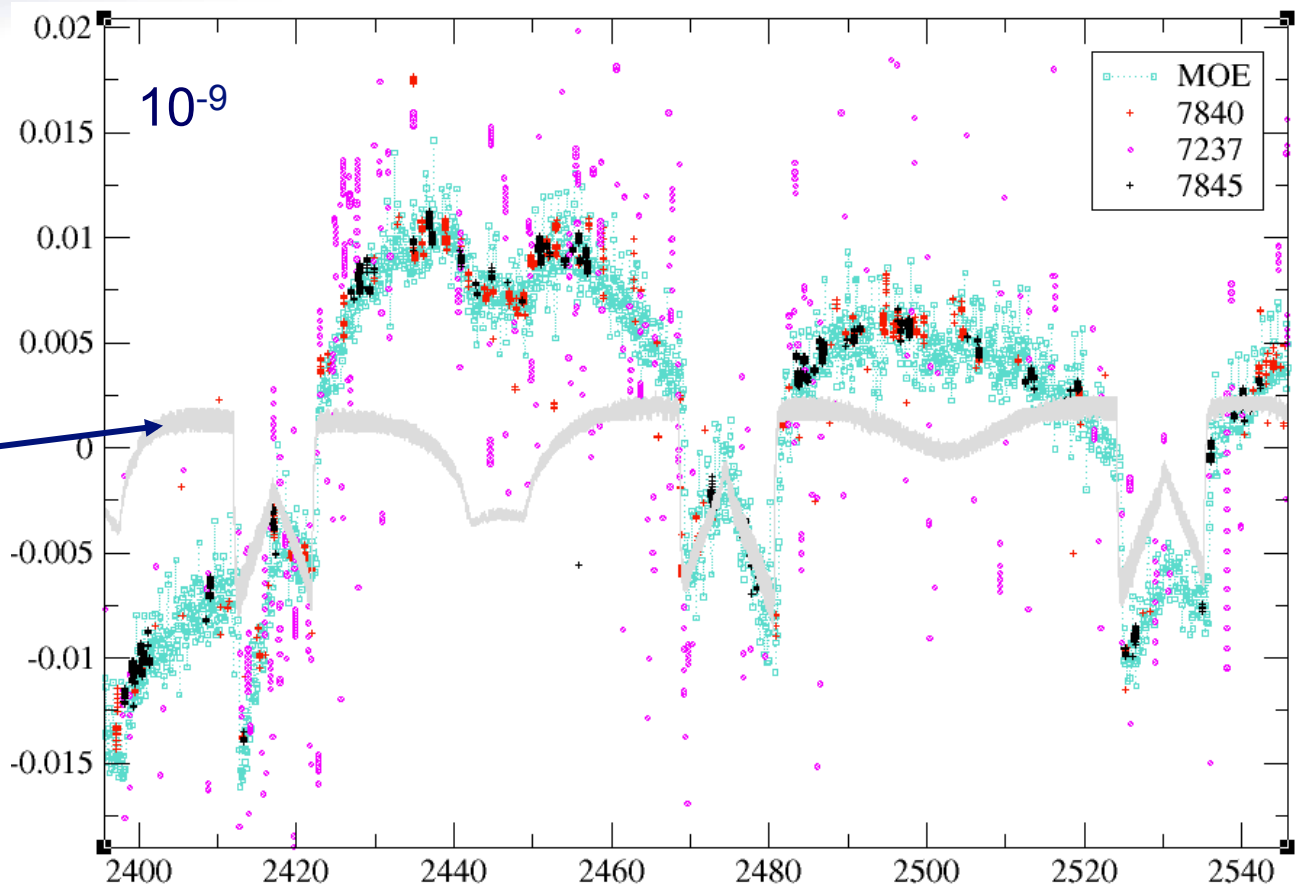
J2



Frequency biases: data (Jason-2)

Data used:
MOE
SLR stations (T2L2)

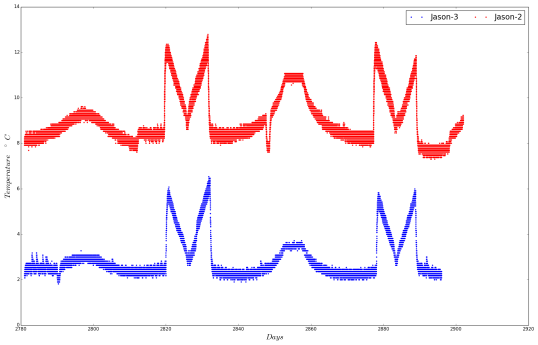
Temperature of the box
=> df/f_0 with 1.85 10^{-12} /degree



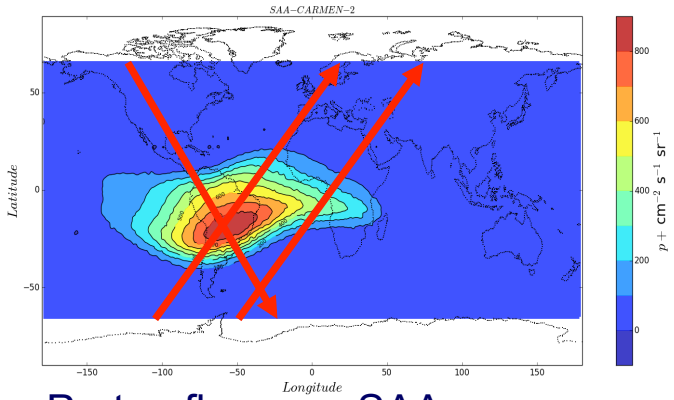
Days (Jas2, June 20 2008) : here 2015

DORIS USO modeling

Temperature of the boxes provided by CNES, for J2 (red: 9°C) and J3 (blue: 3°C)

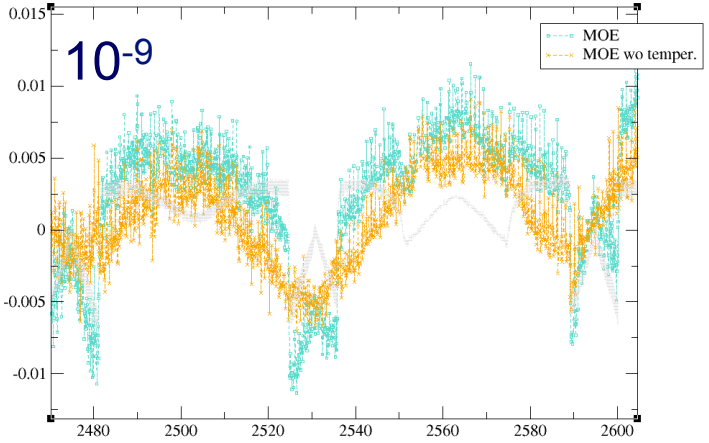


Temperature



Proton flux over SAA
(Carmen /Jason-2: [*Boscher, Bourdarie*])

Frequency biases MOE and temperature modeling (in $\delta f / f_0$), during 2015



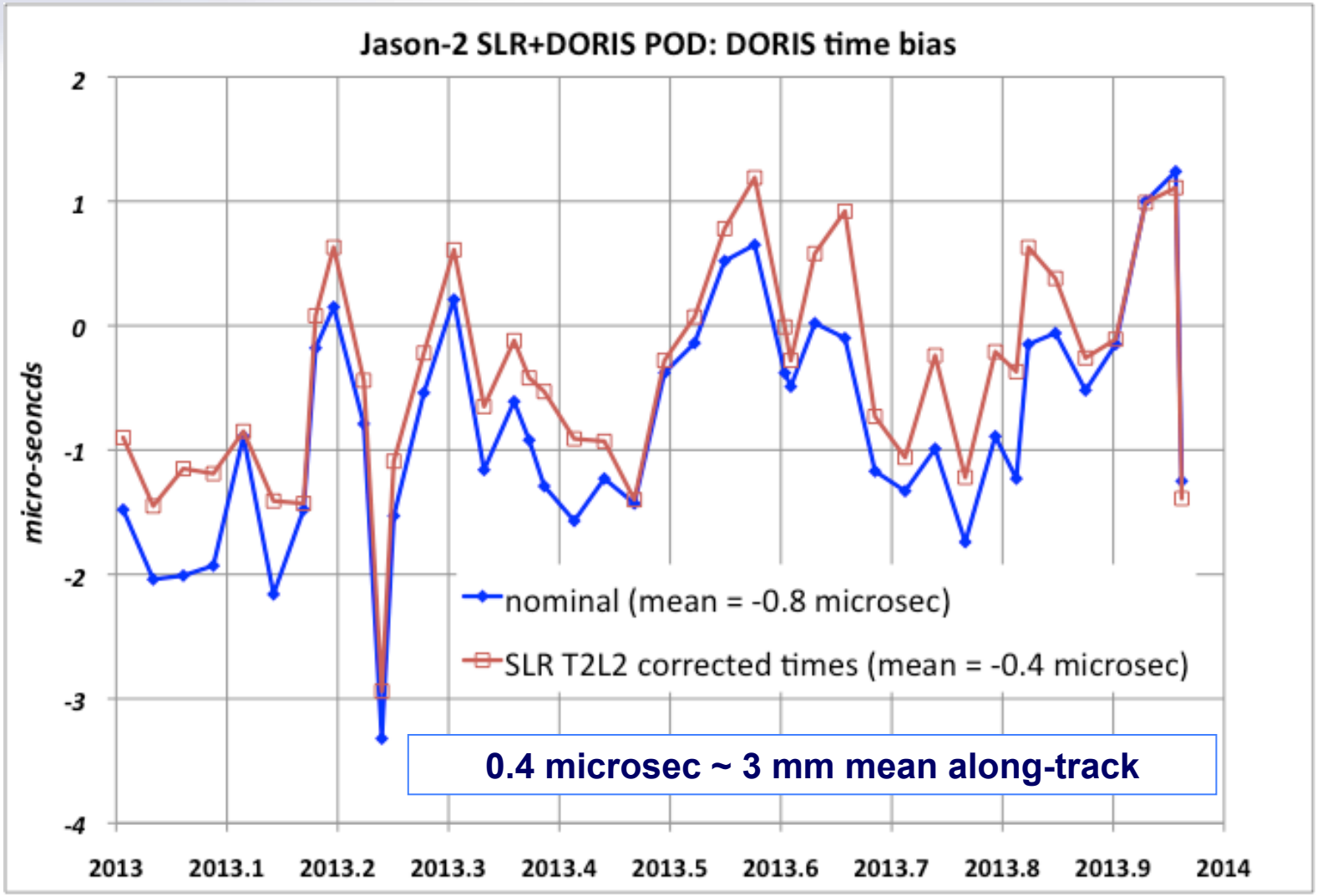
Jason-2 SLR+DORIS POD
using 2013 SLR data with T2L2 corrected time tag

The T2L2 corrected SLR stations (20):

1824	1873	1893	7080	7090	7105
7110	7119	7124	7237	7403	7406
7111	7501	7810	7821	7824	7825
7112	7838	7840	7845	7941	8834

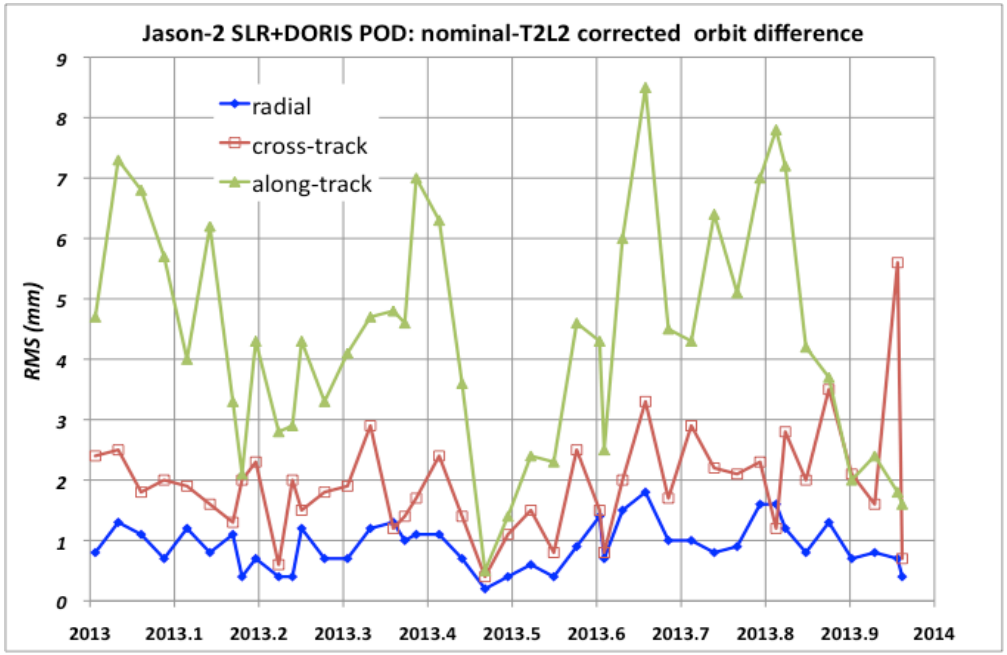
POD tests using latest GSFC dpod2014 POD standards

Jason-2 corrected orbits (T2L2 time biases)



Jason-2 corrected orbits (T2L2 time biases)

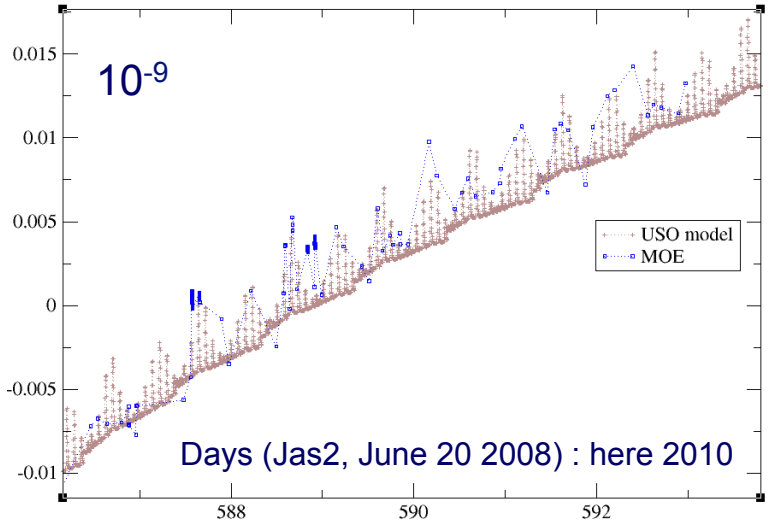
As expected, the improvement
Is on the along-track component
of the orbit,
in addition to SLR orbit residuals
per station



Orbit differences over 2013 (mm)	radial RMS	cross-track RMS	along-track RMS	along-track Mean
nominal-t2l2	0.9	1.9	4.4	2.9
jpl16a-nominal	6.9	21.7	28.9	-4.3
jpl16a-t2l2	6.9	21.7	28.3	-1.2
gdre-nominal	7.1	21.3	27.5	-2.5
gdre-t2l2	7.1	21.3	27.3	0.5

Conclusion & future prospects

1/ The USO frequency model has been completed
a)The initial model ($\delta f / f_0$; *Belli*) has been updated, and is available continuously; the RMS of the fit is of 1.14 10^{-12} for 2010 (1-yr)
b)The comparison between J2 & J3 is under development; a priori, the J3-USO is 2 times more sensitive than J2.



2/ The Time Biases of SLR stations slightly improve the Jason orbit;
a)These corrections move the DORIS measurement time bias closer to zero.
b)They move the orbit closer to the JPL&GDRE orbits in the RMS and Mean along-track component.

A] The DORIS data files (V2) will be corrected for a 1-yr test, first for Jason-2, then for Jason-3

B] SLR-TB degrade the estimated east-west station position; analyses will be conducted into the AWG-ILRS; but there some consequences in using SLR data currently for altimetry missions

Conclusion & future prospects

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Time biases in Laser Ranging observations: a concerning issue of Space Geodesy

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Abstract

Time transfer by Laser Ranging (LR) recently demonstrated a remarkable stability (a few ps over ~ 1,000 s) and accuracy (< 1 nanosecond (ns)) in synchronizing both space and ground clocks over distances from a few thousands to tens of thousands kilometers. Given its potential role in navigation, fundamental physics and metrology, it is crucial that synergy between laser ranging and Time&Frequency (T/F) technologies improves to meet the present and future space geodesy requirements. In this article, we examine the behavior of T/F systems that are used in LR tracking stations of the international laser ranging service. The approach we investigate is to compute time synchronization between clocks used at LR stations using accurate data of the Time Transfer by Laser Link (T2L2) experiment onboard the satellite Jason-2 (Samain et al. 2014). Systematic time biases are estimated against the UTC time scale for a set of 22 observing stations in 2013, in the range of zero to a few µs. Our results suggest that the ILRS network suffers from accuracy issues, due to time biases in the laser ranging observations. We discuss how these systematic effects impact the precise orbit determination of LAGEOS geodetic satellites over a 1-year analysis, and additionally give a measure of the local effect into station coordinates, regarding in particular the effect in the east-west component that is of 2-6 mm for a typical systematic time bias of one µs.

Keywords

Time transfer; Laser ranging; Time bias; Space geodesy

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