IGS INTERNATIONAL GNSS SERVICE

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Acceleration corrections for reducing GPS-related LOD bias in multi-GNSS processing

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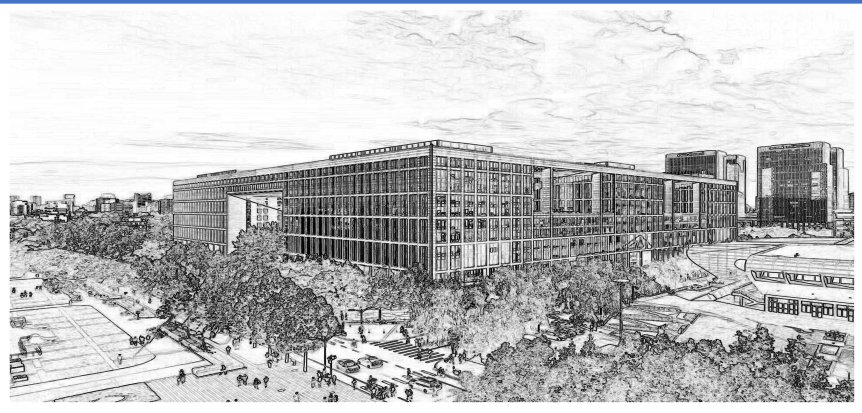

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Abstract

A significant bias relative to the reputable International Earth Rotation Service (IERS) C04 product exists in the Length-Of-Day (LOD) when Global Positioning System (GPS) data is used. An empirical satellite dynamic model is proposed to mitigate such bias, from which acceleration corrections for each GPS satellite is applied in the Earth Rotation Parameters (ERP) determination. Results utilizing multi-GNSS systems including GPS, GLONASS, BDS-3, and Galileo show that the application of acceleration corrections reduces the average of LOD difference from 13.9 to 4.7 µs, and decreases the Root-Mean-Square (RMS) from 23.9 to 13.4 µs.

Methodology

- **An empirical model for representing LOD bias**

Sine once-per-revolution item in the cross-track direction

Constant in the along-track direction

$$\Delta LOD_0 = -\frac{3\cdot\cos i}{a}\cdot t_0\cdot \boxed{A_0} - \frac{\sin i}{2n\cdot a}\cdot\sin\theta\cdot\boxed{C_{C1}} + \frac{\sin i}{2n\cdot a}\cdot\cos\theta\cdot\boxed{C_{S1}}$$

Cosine once-per-revolution items in the cross-track direction

- **Calculation of acceleration correction**

$$\boldsymbol{acc}_{cor} = \boxed{\boldsymbol{acc}_0} + \Delta a\tilde{c}c_A\cdot\boldsymbol{e}_A + \Delta a\tilde{c}c_C\cdot\boldsymbol{e}_C$$

Acceleration obtained from traditional perturbation model

- **Implementation of the proposed method**

Determine A_0, C_{C1} and C_{S1} with ERP fixed to the reference product, e.g., IERS C04

↓

$\tilde{A}_0, \tilde{C}_{C1}, \tilde{C}_{S1}$

↓ $\Delta a\tilde{c}c_A = \tilde{A}_0$ $\quad \Delta a\tilde{c}c_C = \tilde{C}_{C1}\cdot\cos(u+\theta) + \tilde{C}_{S1}\cdot\sin(u+\theta)$

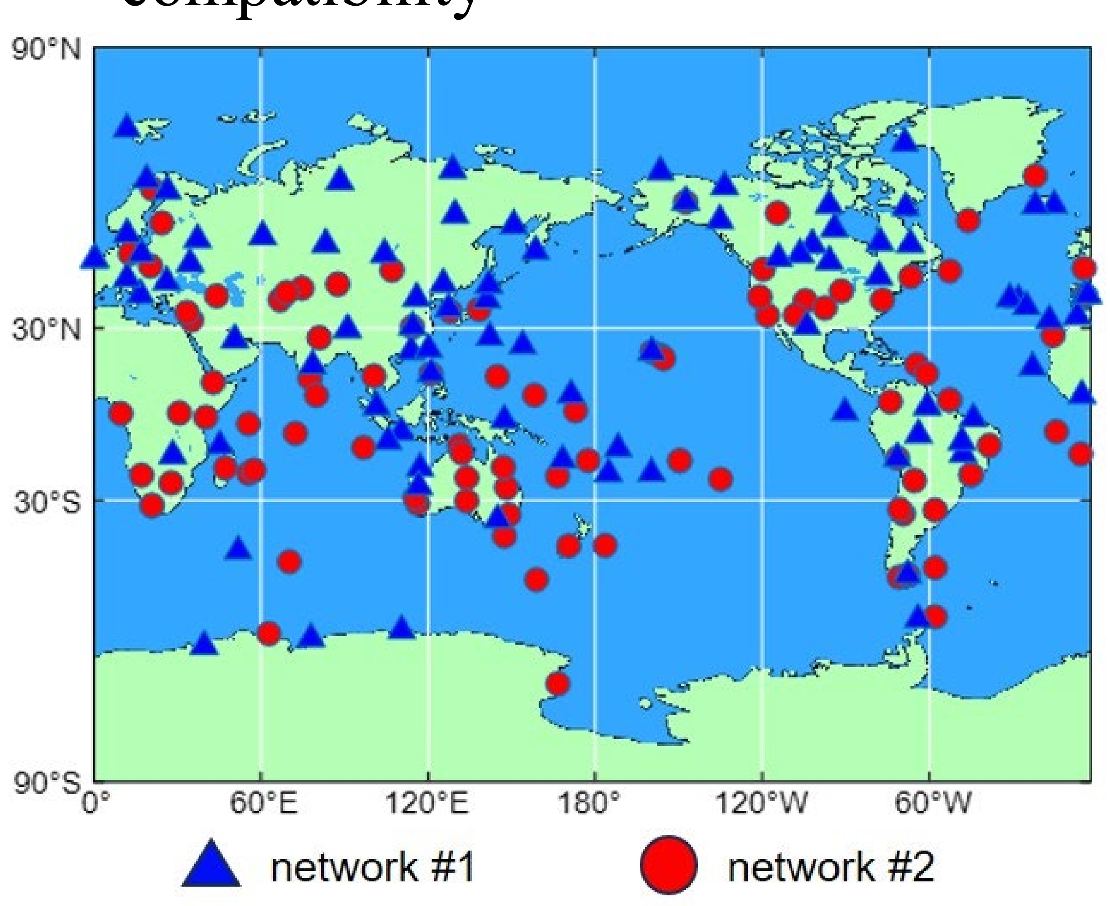
ERP determination

↓

Improved LOD

Data collection and processing strategy

- Period: 1 Jan. 2019 to 1 June 2022
- Two networks for validating compatibility



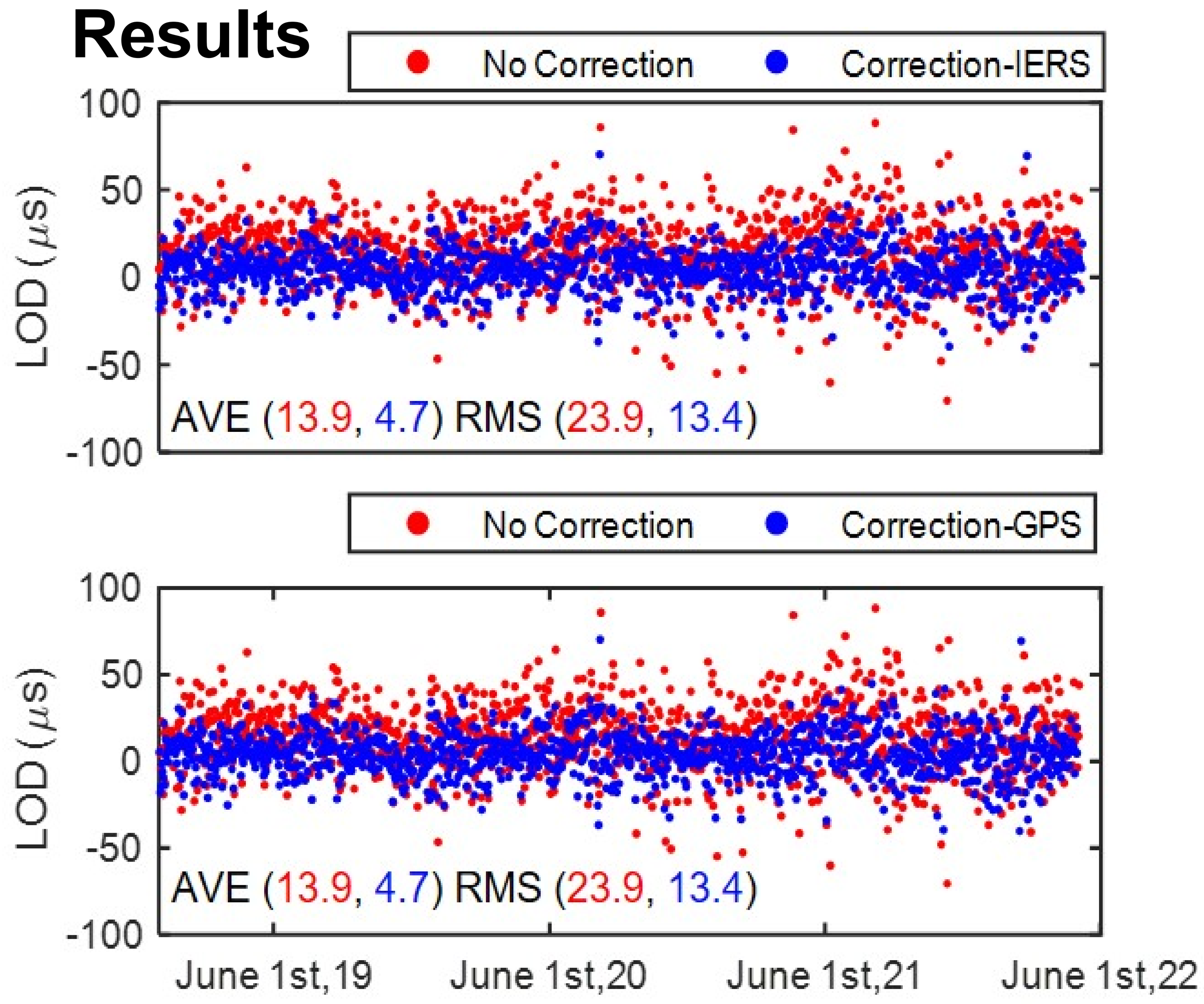
Distribution of selected stations

network #1: producing corrections

network #2: determining ERP

Items	Description
Software	GSTAR
Frequency	L1 and L2
Arc length	24 h
Process interval	300 s
SRP model	7-parameter ECOM2

Results



LOD difference relative to the IERS C04 product

- No Correction: Not applying corrections
- GPS: GPS-based solution as initial ERP in the ERP determination
- IERS: IERS C04 product as initial ERP

Average for pole coordinates (µas) differences and polar rates differences (µas/d)

Pole Motion	No Correction	Correction -IERS	Correction -GPS
X_P	-16.8	-15.9	-15.9
Y_P	7.5	4.9	5.1
X_P rate	-38.4	2.4	1.9
Y_P rate	12.4	-0.6	0.2

RMS for pole coordinates (µas) differences and polar rates differences (µas/d)

Pole Motion	No Correction	Correction -IERS	Correction -GPS
X_P	59.4	57.2	57.2
Y_P	49.2	43.1	42.9
X_P rate	132.9	102.0	101.6
Y_P rate	161.6	157.6	156.2

Conclusion

Applying acceleration corrections for GPS satellites in multi-GNSS processing are beneficial to improving the accuracy of ERP components including LOD, pole coordinates and polar motion rates. In the results of ERP determination, there is no notable discrepancy between the results obtained when utilizing the IERS C04 product and a GPS-based solution as the initial ERP value, respectively.