Precise point positioning with ambiguity resolution (PPP-AR) working group

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Context

Precise satellite orbit and clock corrections produced by the IGS are used by many for the purpose of computing precise point positioning (PPP) solutions. For 24-hour solutions in static mode, PPP can provide millimeter-level accuracies for all components (latitude, longitude and height). Since PPP processes undifferenced observations, it also provides useful information on other error sources affecting GNSS observations such as receiver clocks, tropospheric delays and slant ionospheric delays.

For about a decade now, techniques were developed to fix undifferenced ambiguities in PPP. Similar to a network solution, ambiguity resolution provides improved estimates for user parameters. Studies have demonstrated a 30% improvement in the longitude component, enhanced receiver clock stability estimates, and reduced errors in PPP-derived atmospheric delays. PPP with ambiguity resolution (PPP-AR) can also significantly improve the accuracy of short observation sessions, which is especially beneficial for fieldwork in many industries.

With PPP-AR having matured sufficiently since its inception, and with more IGS analysis centers (ACs) producing products enabling PPP-AR (currently: CNES, NRCan, Wuhan and CODE), the timing is right for the IGS to start investigating a combined version of these products. Different from standard clock products produced by the IGS, PPP-AR products only retain their consistency when considering simultaneously both the satellite clock and bias (code and phase) corrections. There is, however, no impact on the combined orbit products.

The PPP-AR working group will investigate the development of a modernized combination process taking into consideration both satellite clocks and biases. Improvements to the current clock combination process shall also be considered, such as: satellite attitude during eclipse periods, day boundary discontinuities, and the inclusion of multiple GNSS constellations. It should also be noted that all ACs can contribute to such a clock/bias combination, although the combined phase-bias products would be determined solely from ACs contributing PPP-AR products. The goal of the PPP-AR WG is, therefore, to analyze the feasibility and benefits of having the IGS adopt a modernized clock/bias combination process.

Goals

Phase 1

- Survey the technical practices, requirements, and goals of the participating ACs currently producing PPP-AR products
- Encourage maximum participation with a target of a minimum of three analysis centers generating reliable PPP-AR products
- Propose the adoption of a satellite attitude exchange format as a necessary step to ensure compatibility of clock solutions
- Assess whether current data formats are adequate to convey all information related to PPP-AR clocks/biases, and explore extension and additions, if necessary
- Examine the inter-operability of PPP-AR products generated by various analysis centers
- Develop a modernized satellite clock/bias combination software
- Generate combined clocks and biases for internal tests
- Communicate the performance of combined PPP-AR products to the GNSS community in comparison to the corresponding products of the contributing ACs

Phase 2

- Work with the Bias WG to ensure continuity of clocks/biases at day boundaries by using the integer properties of the combined products
- Work in partnership with the Clock WG on time scale issues associated with continuous “phase“ clocks
- Test and pilot a modernized and fully integrated clock/bias combination software
- Initiate a pilot project to expose the combined clock/bias solution to open testing
- Make recommendations to the GB about adding a combined clock/bias solution as an official IGS AR product

Members

The following table contains a list of people who are supporting the PPP-AR WG initiative and willing to contribute products and/or expertise. This list is likely to grow as more people are aware of the WG.

Name	Organization	Email	Role
Simon Banville	NRCan	simon.banville@canada.ca	Chair
Yoaz Bar-Sever Larry Romans Ant Sibthorpe	JPL	Yoaz.E.Bar-Sever@jpl.nasa.gov	Analysis center contribution (future)
Michael Coleman	NRL	Michael.Coleman@nrl.navy.mil	Time alignment advisor
Jianghui Geng	Wuhan University	jgeng@whu.edu.cn	Analysis center contribution
Denis Laurichesse	CNES	Denis.Laurichesse@cnes.fr	Software development
Sylvain Loyer	CLS	sloyer@groupcls.com	Analysis center contribution
Benjamin Maennel	GFZ	benjamin.maennel@gfz-potsdam.de	ACC 2.0 contribution
Michael Moore	GA	michael.moore@ga.gov.au	Analysis center coordinator (ACC)
Gérard Petit	BIPM	gpetit@bipm.org	Clock analysis
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Stefan Schaer	CODE	stefan.schaer@aiub.unibe.ch	Analysis center contribution
Baocheng Zhang	CAS	b.zhang@whigg.ac.cn	Technical analysis