COPERNICUS POD SERVICE
single-receiver ambiguity resolution for sentinel satellites

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ABSTRACT

In the pursuit of better POD (Precise Orbit Determination) accuracies, the single receiver ambiguity resolution is a necessary technique. This constrains the POD solution allowing to increase the accuracy of the orbit solutions, and allowing to set up empirical parameters more targeted. In network-based GNSS processing, the use of double-differences removes the emitter and receiver uncalibrated biases, and therefore, the carrier phase ambiguities can be fixed to their integer values. However, for orbiting receivers in a stand-alone processing, it is necessary to correct the emitter uncalibrated biases directly. Currently, there are several options to do so: the GPS wide-lane bias product from CNES/CLS (Laurichesse et al. 2009) is widely used but also other products recently became available, like the CODE bias product (Arnold et al. 2019). In this study, we will show the different schemes, its advantages and disadvantages from an operational point of view, the differences and stabilities of the biases, and the orbital accuracy results obtained using them. The operational element is relevant to the Copernicus POD Service, which is currently computing the precise orbits of the Copernicus Sentinel-1, -2 and -3 satellites. The goal to use single-receiver ambiguity resolution to short timeliness will be assessed.

References

Laurichesse D., Mercier F., Berthias J.P., Broca P., Cerri L., 2009. Integer ambiguity resolution on undifferenced GPS phase measurements and its application to PPP ad satellite precise orbit determination

Arnold D., Schaer S., Villiger A., Dach R., Jäggi A., 2019. Single-receiver ambiguity fixing for GPS-based precise orbit determination of low Earth orbiters using CODE's new clock and phase bias products

Fernández J., Peter H., Calero E.J., Berzosa J., Gallardo L.J., Féménias P., 2019. Sentinel-3A – Validation of Orbit Products at the Copernicus POD Service

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OPERATIONAL AMBIGUITY-FIXING FOR COPERNICUS POD SERVICE

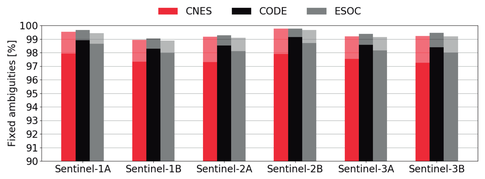
- Latency of the operational products per mission (critical for ambiguity-fixing)

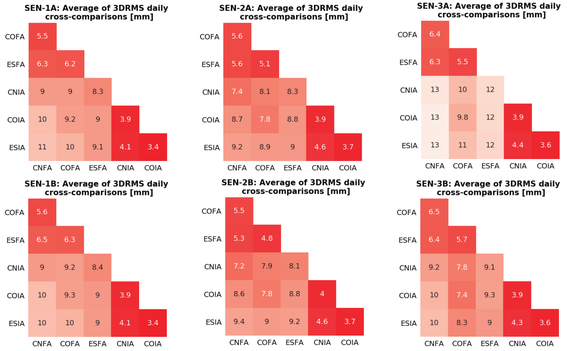
	Category	Latency
Sen-1	NRT	180 min.
	NTC	20 days
Sen-2	NRT (predicted)	90 min. before ANX
	NRT	30 min.
Sen-3	NRT	30 min.
	STC	30 min.
	NTC	25 days

- New inputs required
  - CNES/CLS routinely provides **wide-lane satellite biases (WSB)** with a timeliness of 5-12 days → **Ambiguity-fixing only applicable for NTC products**
  - CODE generates phase biases internally. These products are not routinely circulated to external users yet.
  - ESOC generates undifferenced phase delays (UPDs) internally. These products are not routinely circulated to external users yet.

PROCESSING AND TRIAL DATA SET

- CNES/CLS WSB products retrieved from IGS archive
- CODE and ESOC have provided a trial data set of phase bias products and UPDs, respectively, from **23/09/2018** to **26/01/2019** (126 days) → POD processing with 126 days of data using new dynamical models (Peter et al. 2019)
- Float (FA) and integer (IA) ambiguity solutions generated for each provider:
  - **CNFA**: FA solution using CNES/CLS products
  - **CNIA**: IA solution using CNES/CLS products
  - **COFA**: FA solution using CODE products
  - **COIA**: IA solution using CODE products
  - **ESFA**: FA solution using ESOC products
  - **ESIA**: IA solution using ESOC products
- **Similar fixing performance for each provider and satellite (fixing rate ~98%)**





Higher synergy/correlation between IA solutions: **improvement in consistency**

1-point overlaps at midnight [mm]

	SEN-1A	SEN-1B	SEN-2A	SEN2B	SEN-3A	SEN-3B
CNFA	4.61 ± 2.48	5.55 ± 2.89	4.85 ± 2.05	4.73 ± 2.10	6.33 ± 3.48	6.15 ± 2.77
COFA	4.14 ± 2.08	4.94 ± 2.44	4.49 ± 1.87	4.78 ± 2.26	6.14 ± 3.40	5.65 ± 2.87
ESFA	5.25 ± 2.82	5.57 ± 2.67	4.47 ± 2.11	4.70 ± 1.94	6.08 ± 3.08	5.99 ± 3.09
CNIA	3.60 ± 1.97	3.52 ± 1.75	3.43 ± 1.55	3.56 ± 1.63	4.44 ± 2.09	4.32 ± 1.99
COIA	3.54 ± 1.88	3.56 ± 1.63	3.34 ± 1.33	3.47 ± 1.53	4.24 ± 1.90	4.13 ± 1.79
ESIA	3.73 ± 2.11	3.51 ± 1.71	3.51 ± 1.48	3.56 ± 1.56	4.37 ± 1.84	4.14 ± 1.81

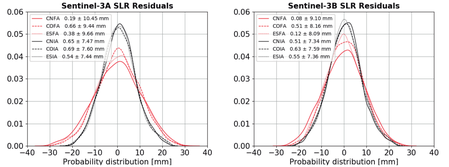
Smaller overlaps for IA solutions: **improvement in repeatability**

Baseline solution generated from combining the **POD QWG** orbits (Fernández et al., 2019)
IA solutions are closer to the baseline solution: **improvement in accuracy** (especially for Sentinel-3)

Comparisons against baseline solution – 3D RMS [mm]

	SEN-1A	SEN-1B	SEN-2A	SEN2B	SEN-3A	SEN-3B
CNFA	14.47 ± 2.00	14.92 ± 2.24	10.98 ± 0.94	11.08 ± 1.06	18.29 ± 1.27	13.11 ± 1.15
COFA	13.79 ± 1.87	14.31 ± 1.86	10.18 ± 0.87	10.21 ± 0.94	15.91 ± 0.97	11.56 ± 1.01
ESFA	14.33 ± 1.87	14.80 ± 2.10	10.91 ± 0.91	10.91 ± 1.03	17.32 ± 1.49	12.57 ± 1.23
CNIA	13.55 ± 1.78	13.20 ± 1.69	10.38 ± 0.80	10.81 ± 0.88	11.98 ± 0.75	10.23 ± 0.89
COIA	13.75 ± 1.82	13.43 ± 1.71	10.48 ± 0.82	10.96 ± 0.80	12.35 ± 0.71	10.50 ± 0.84
ESIA	14.02 ± 1.83	13.63 ± 1.70	11.14 ± 0.99	11.69 ± 0.88	12.76 ± 0.84	10.66 ± 0.83

SLR residuals after removing a common bias per station (Peter et al.)
Lower SLR dispersion for IA solutions: **improvement in accuracy**



CONCLUSIONS

- Ambiguity fixing capabilities have been implemented in the tools of the CPOD Service, handling different products.
- A first analysis of the trial data set provided by CODE and ESOC has been presented and compared against the CNES/CLS solutions, showing a promising performance.
- Improvements in accuracy, repeatability and consistency have been proven for the IA solutions.
- Similar figures have been found using the CNES/CLS, CODE and ESOC products.

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