CLS
COLLECTE LOCALISATION SATELLITES

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

IGS 2026 WORKSHOP
SANTIAGO DE CHILE
33°26' S 70°39' O

IDEFIX: An algorithm for the comparison and validation of fixed ambiguities

Georgia Katsigianni[1], Sylvain Loyer[1], Alvaro Santamaria[2],

[1]Collecte Localisation Satellites (CLS)
[2]Centre National d'Etudes Spatiales (CNES)

Table Of Contents

Introduction – Key Questions

Since the beginning of integer products (suitable for PPP-AR), we aim to address the following questions:

- Is the ambiguity fixing correct/reliable?
- When AR fails, can we identify where it occurs? (beyond the overall ambiguity fixing rate)?
- When fixed ambiguities are common to consecutive days, are they consistent?

Use of statistical indicators/validation tests: % of fixing, success rate, ratio tests, residuals etc.

Impact on GNSS products quality, orbit overlaps, clock overlaps, etc.

Introduction – IGS comparisons & combinations

Today, analyses of GNSS products from different ACs are performed by:

- **Individual product comparisons** (e.g., product quality, orbit/clock comparisons), like legacy IGS final combinations
- **Combined analysis** of all GNSS products as a whole dataset (orbits/clocks/biases/attitude etc.), as done by BAR/WCC experimental combination of PPP-AR products: **global daily statistics**

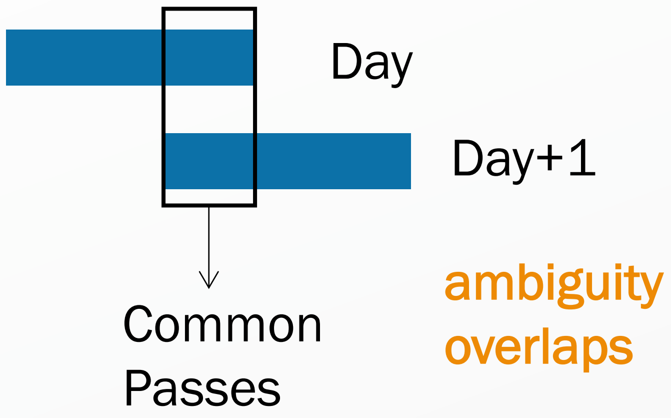
BUT

- The same ambiguity fixing rate (%) in two solutions does not mean same $\mathbb{N}$ values!
- Lack of information of when/where a problem occurs!
- When fixed ambiguities are common to consecutive days, are they consistent?

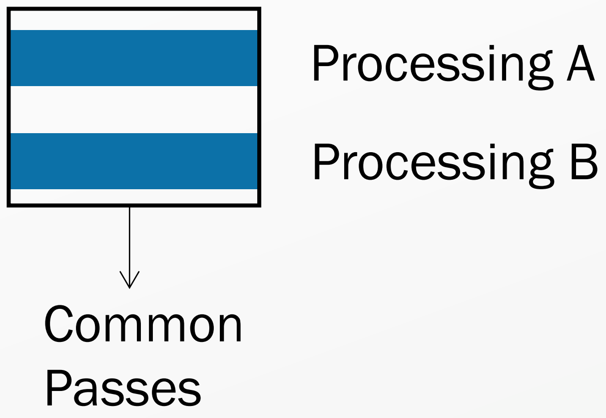
IDEFIX Algorithm

The idea is to check the agreement between 2 different integer ambiguity solutions with common passes at the level of individual satellite-station passes.

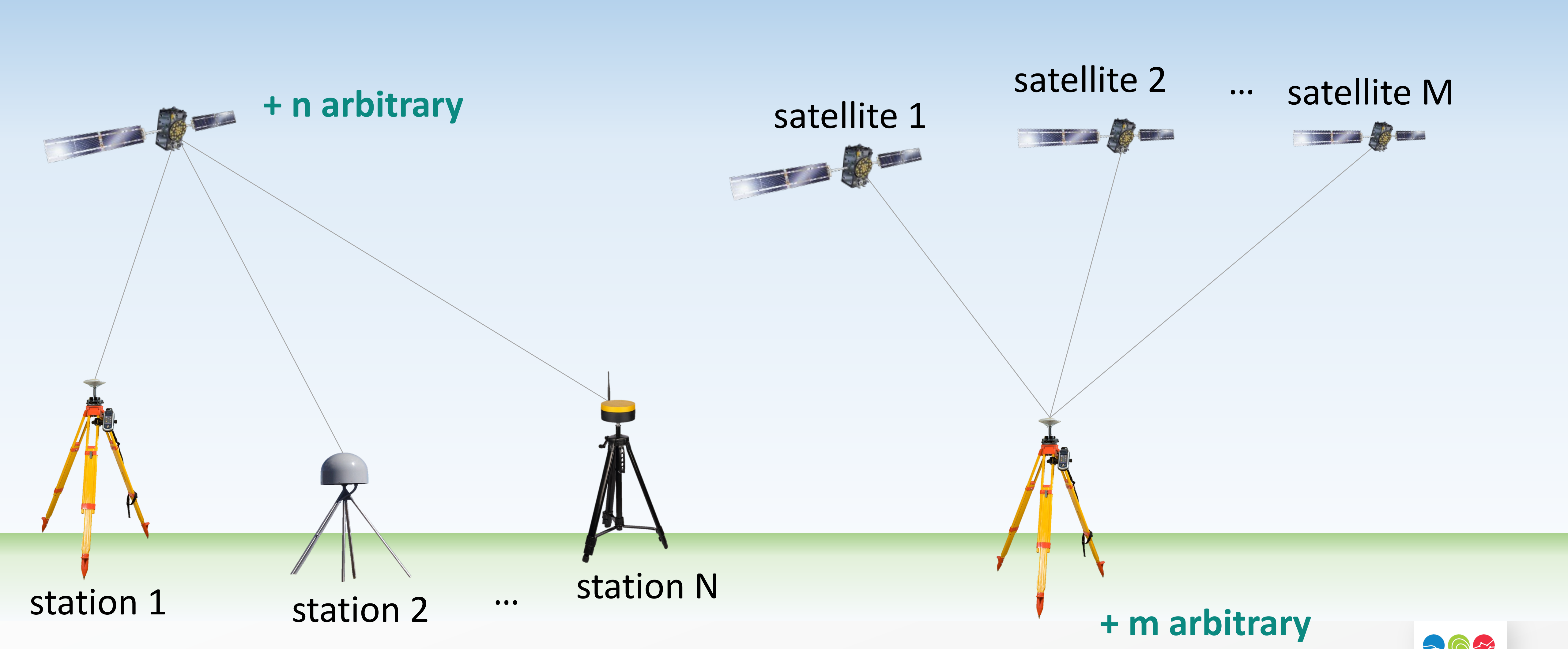
from 2 successive days:



from the same day with different processings:

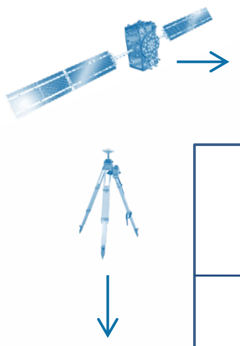


IDEFIX Algorithm



CLS
COLLECTE LOCALISATION SATELLITES

IDEFIX Algorithm



A=

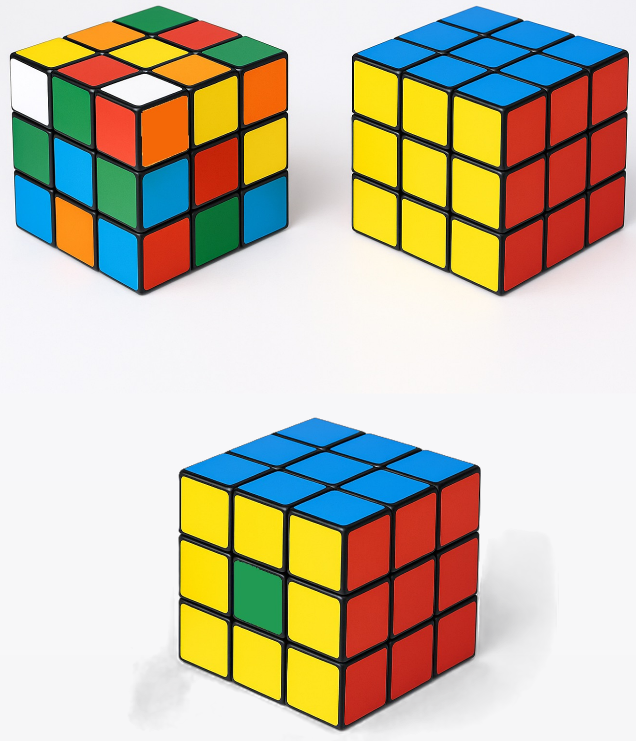
	...+n		
	...+n		
	...+n		
...+m	...+n +m	...+m	...+m

+m

+n

B=

	...+n’		
	...+n’		
	...+n’		
...+m’	...+n’ +m’	...+m’	...+m’



IDEFIX Algorithm

Undifferenced WL fixing after applying OSB

$$\mathrm{MW} = \mathrm{f}(\mathrm{L1} - \mathrm{OSB_{L1}}, \mathrm{L2} - \mathrm{OSB_{L2}}, \mathrm{P1} - \mathrm{OSB_{P1}}, \mathrm{P2} - \mathrm{OSB_{P2}}) = \lambda_{\mathrm{wl}}\boxed{\mathrm{N_{wl}}} + h_{wl}$$

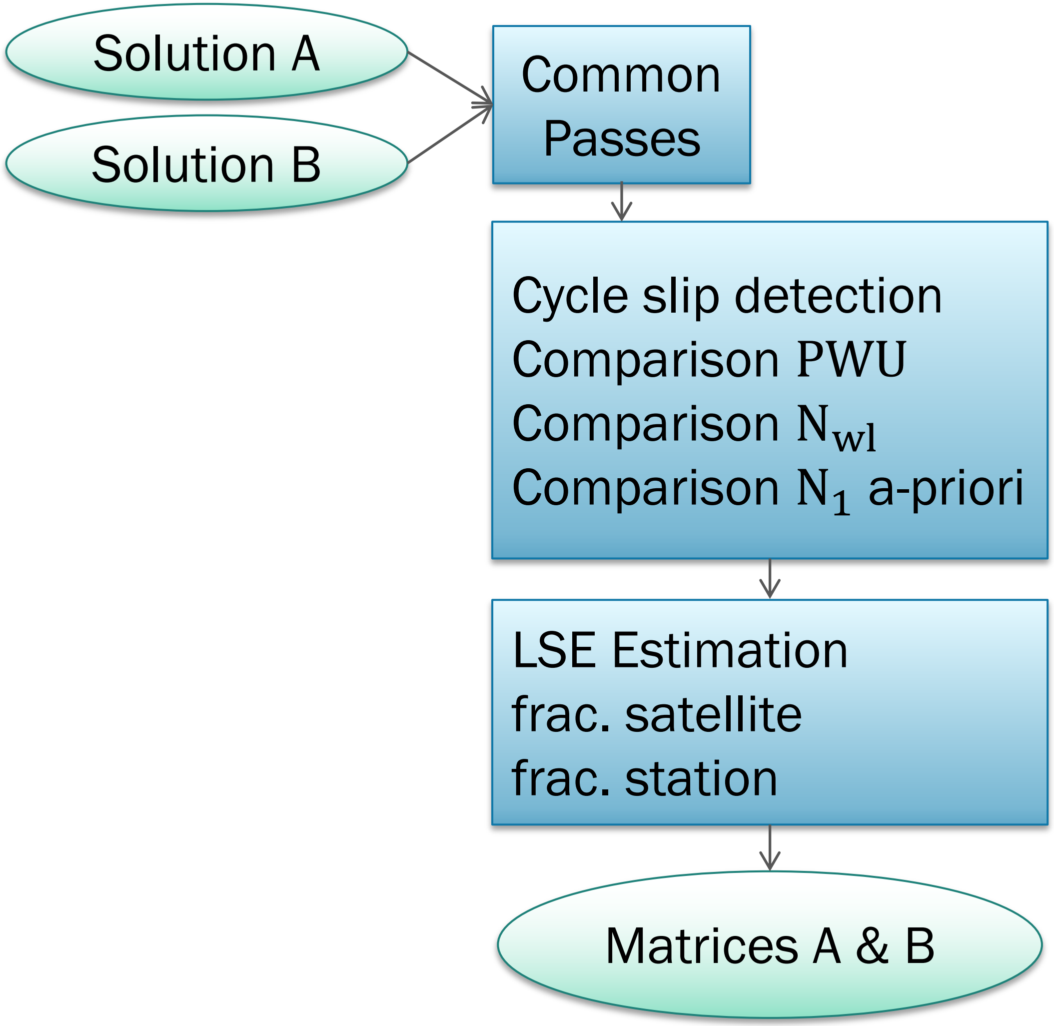
(Common to all sat.)

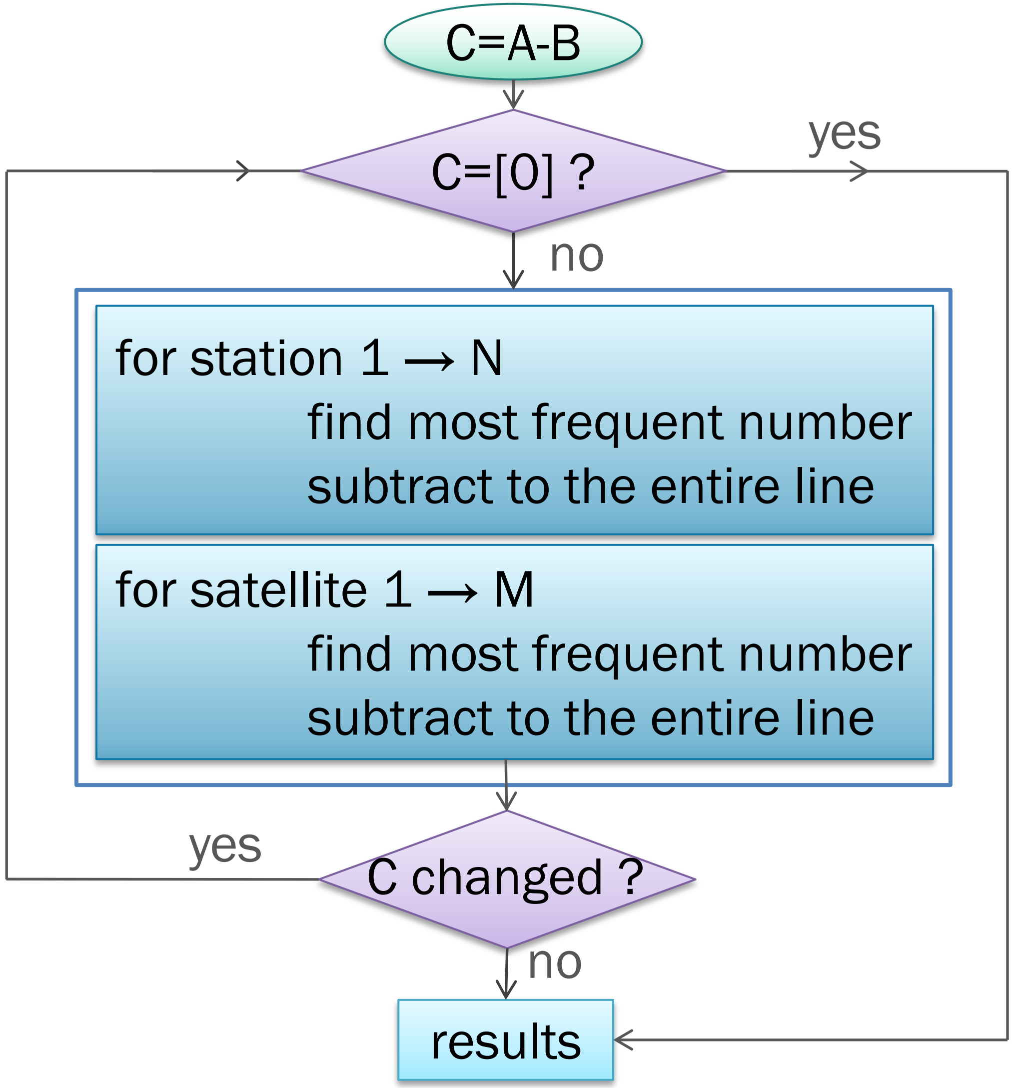
NL fixing

$$\mathrm{L_{IF}} = \rho + c\boxed{\Delta t} + \mathrm{T} + \lambda_{\mathrm{nl}}\boxed{\mathrm{N_1}} + \lambda_{\mathrm{nl}}\boxed{\frac{\lambda_{\mathrm{wl}}}{\lambda_2}\mathrm{N_{wl}}} + \lambda_{\mathrm{nl}}[\mathrm{PWU}(t) - \boxed{\mathrm{PWU}(t_0)}] + \varepsilon_{\mathrm{IF}}^{s}$$

Components involved in ambiguity comparisons

IDEFIX Algorithm





Example POD

CNES/CLS GNSS processing chain

Final weekly GNSS products and global network solution

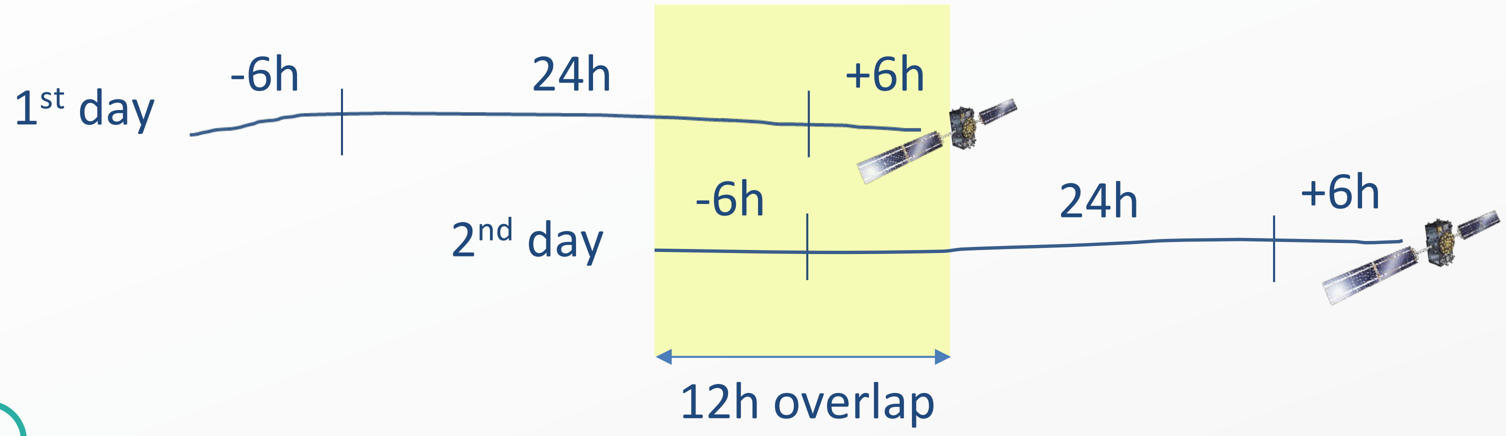
AR method: Integer bootstrapping

Software: GINS

4 months (Jan. – Apr. 2026)

Constellation: GPS & Galileo

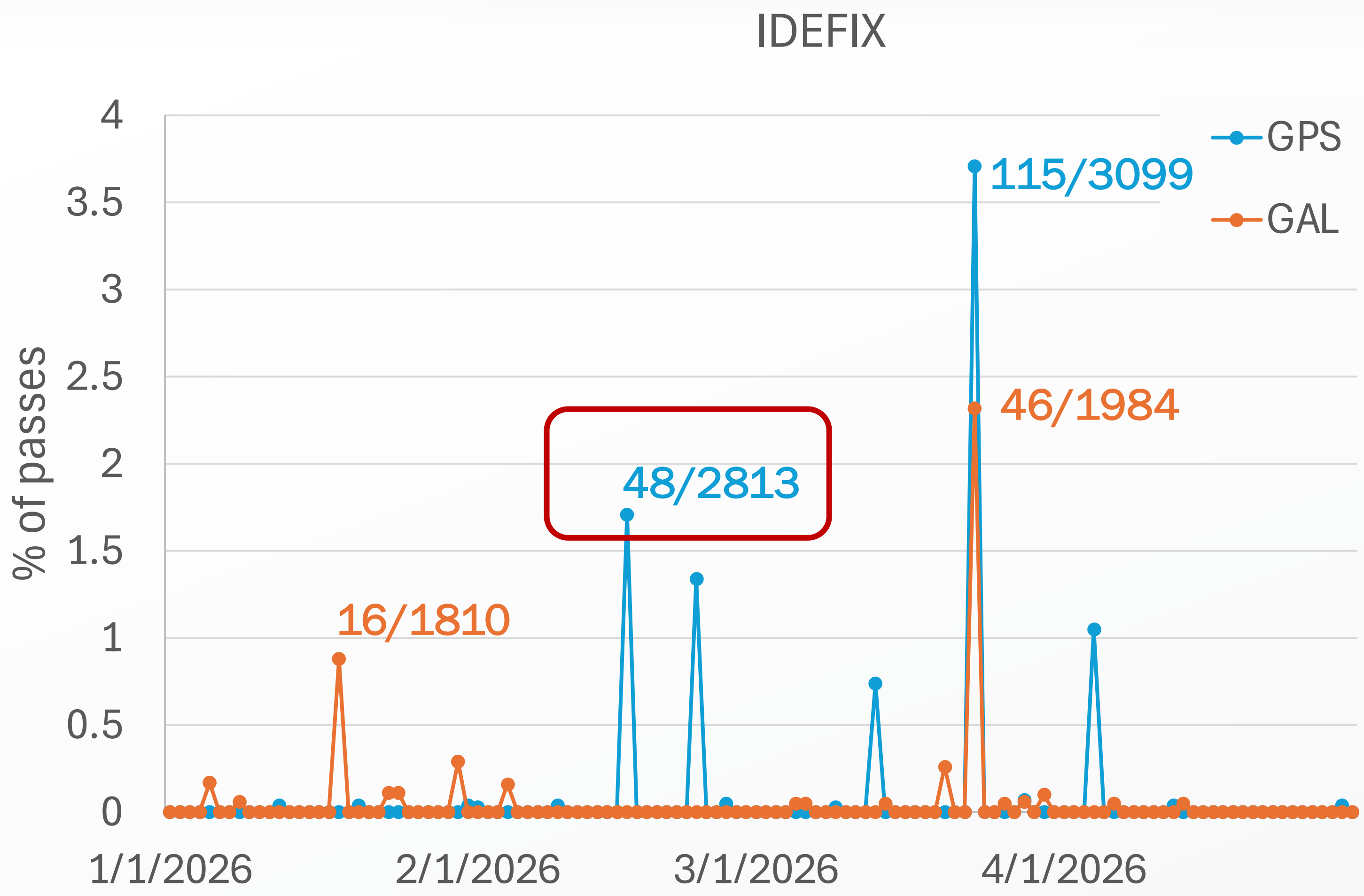
Data: GRGOPSFIN



Results:

IDEFIX ambiguity overlaps

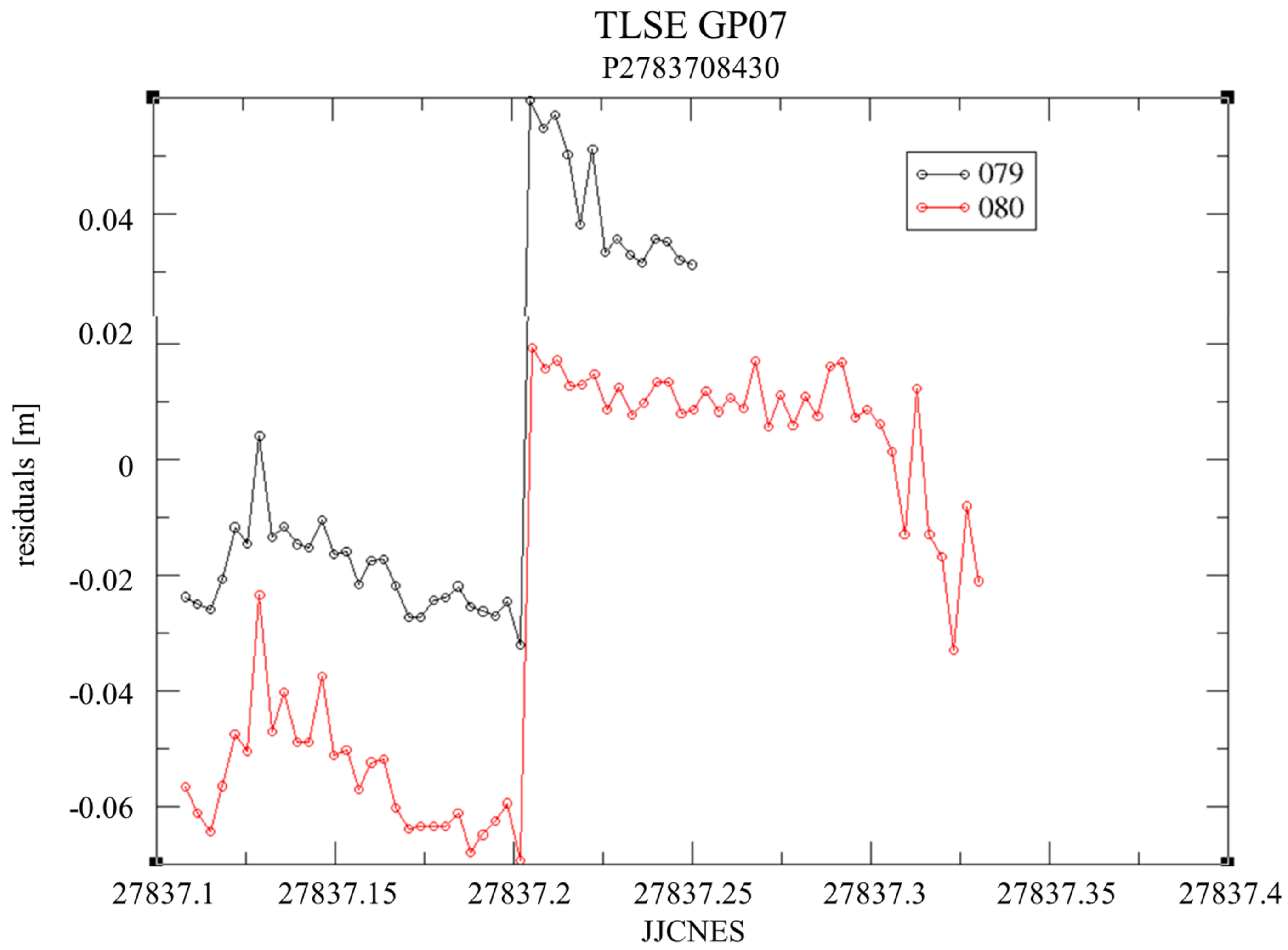
Example POD



% of differences of fixed ambiguity values (i.e. ambiguity overlaps)

- 2700-3200 passes for GPS
- 1600-2000 passes for GAL
- Generally perfect agreement between successive days
- A few inconsistencies …

Example POD



Example: Pass P2783708430 TLSE GPS07 for doy 079-080/2026

Measurement residuals may indicate:

- Problem of measurements
- Problem of processing algorithms
- e.g. this pass shouldn't have been fixed! (undetected cycle slip, additional noisy final part of the pass for doy 080)

Example PPP-AR

Software: GINS

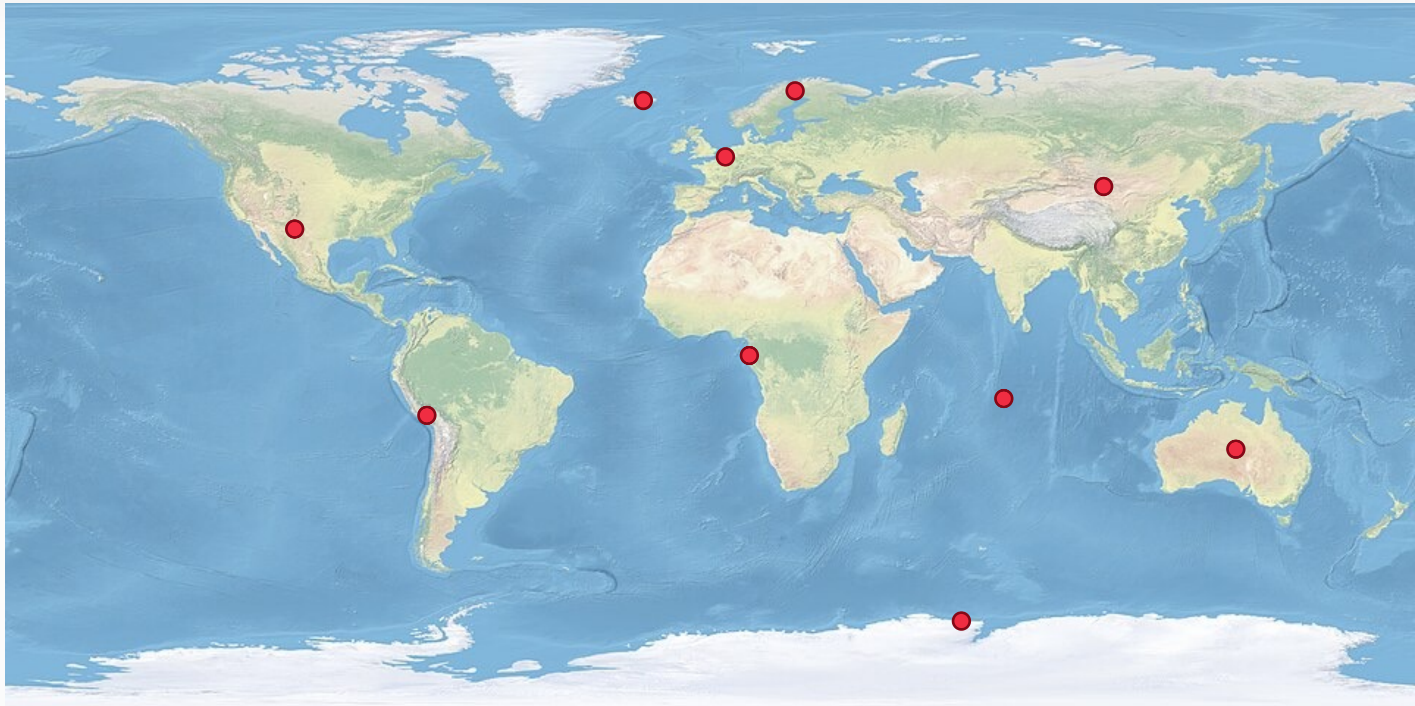
Mode: Static daily PPP-AR

10 global stations

10 days (12-22/01/2026)

Constellation: GPS

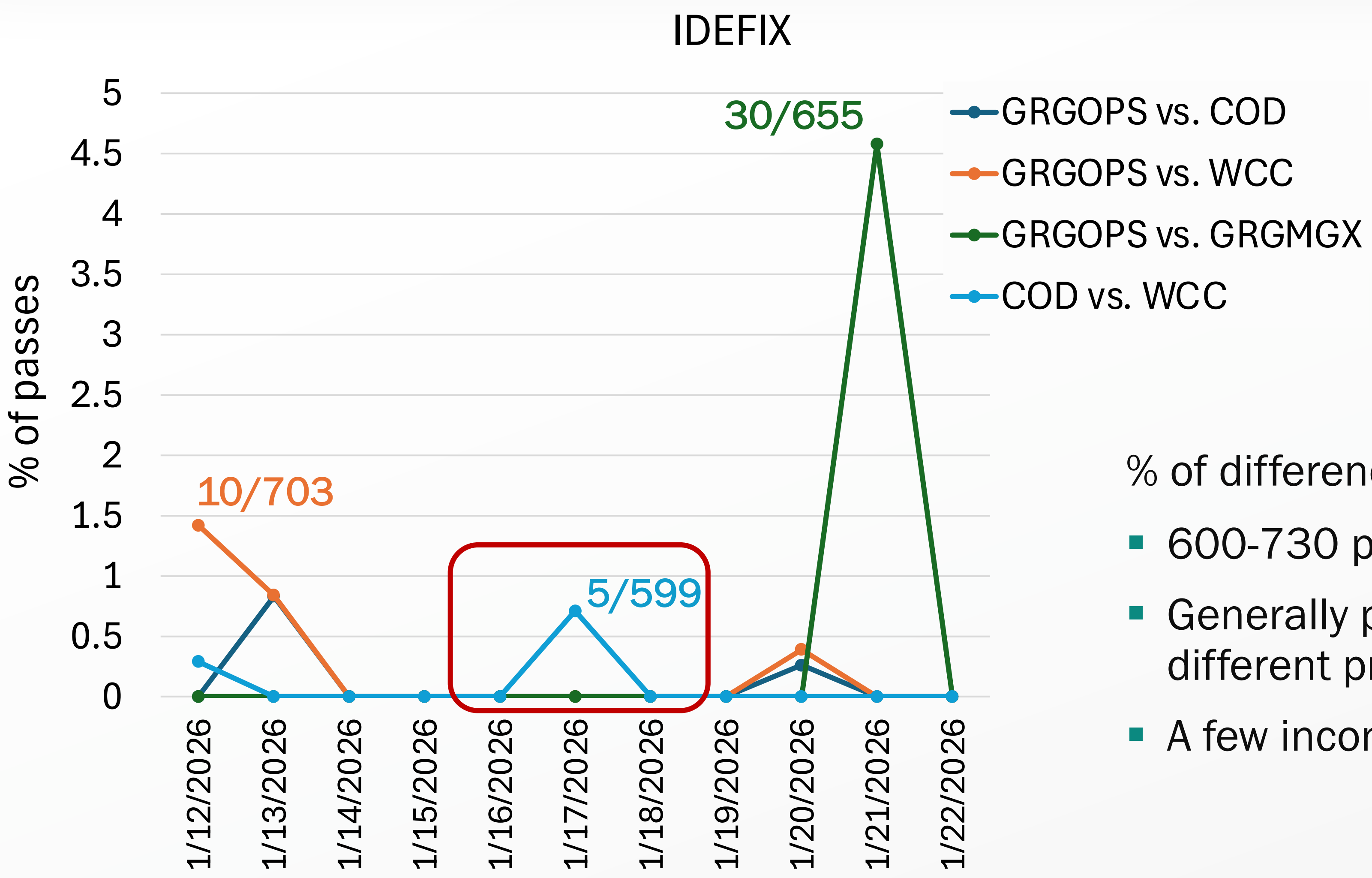
Data: GRGOPSFIN, GRGMGXFIN, CODOPSFIN, WCCOPSFIN



Results:

IDEFIX PPP-AR of different processings

Example PPP-AR



% of differences of fixed ambiguity values

- 600-730 passes for GPS
- Generally perfect agreement between different processings
- A few inconsistencies ...

Example PPP-AR

```
Problems(PBS): non-zero remaining values

PBS PRN       G06  G14  G22  G30
PBS ALIC        1    0    0    1
PBS ULAB        0    3    1    1
```

Position of the amb. differences in the passage matrix

Passage ID   difference (N cycles)

```
PBS     ambiguity                 diff /common length/file1/itype1/file2/itype2 ( 1 = init. )/residuals     frac.
PBS MNA 1200302777115900ULAB        1   13830.0   13830.0 0   17940.0 0       -0.235        -0.232        0.004
PBS MNA 1200142777120880ULAB        3    8280.0    8280.0 0   20160.0 0       -0.529         0.068        0.598
PBS MNA 1200222777123580ULAB        1    6660.0    6660.0 0   18720.0 0        0.529         0.471       -0.058
PBS MNA 1200062777126850ALIC        1    3390.0    3390.0 0    9150.0 0       -0.118        -0.113        0.004
PBS MNA 1200302777128140ALIC        1    1710.0    1710.0 0   28080.0 1       -0.706        -0.232        0.474
```

```
-----
FINAL: (   5/ 599 ) ->    0.83 %
```

Global statistics

Conclusions & Suggestions

- A new idea of **AR comparisons** to detect common passages with inconsistent fixed ambiguities between two solutions
- e.g., ambiguity overlaps, comparison of different processings, AC1 vs AC2 ...
- Detailed comparison of integer ambiguity products **at the level of individual passes** (sub-diurnal resolution)

- May help the detection of local anomalies in the products
- Can contribute to the ACs combination consistency
- Ambiguity Overlaps to enhance product continuity
- Ambiguity comparisons as means to access/improve continuity and of the “integer” BAR combined products

Thank you
Gracias

This work has been supported by CNES French Space Agency under contract 250097/24097.

Meet us: Poster P2 07

CNES/CLS IGS Analysis Center 2024/2026 Activities

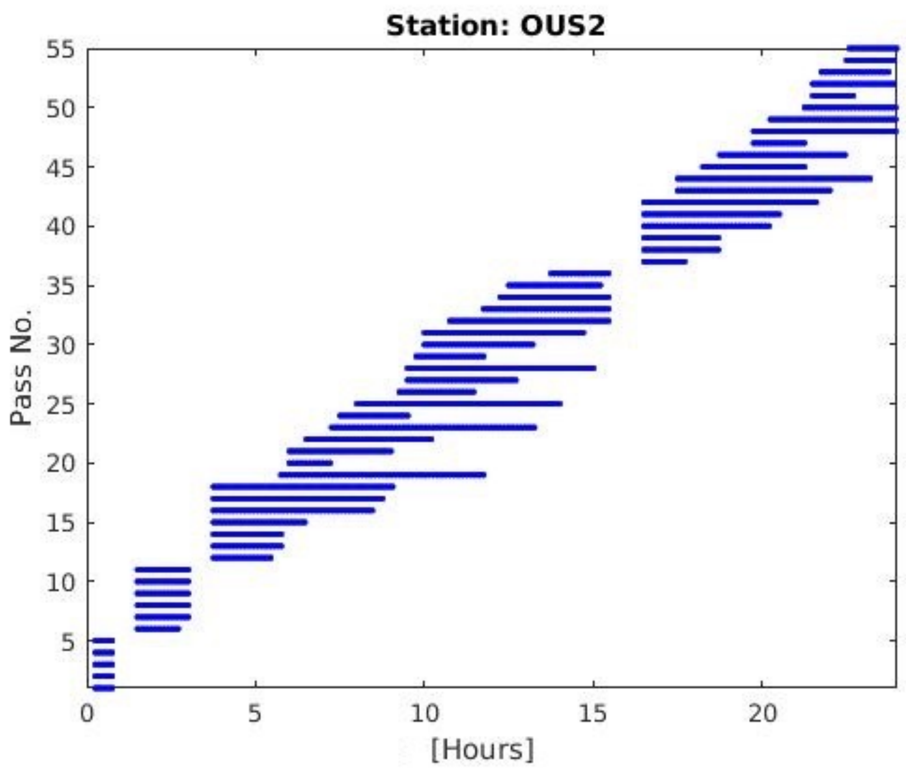
Contact us: igs-ac@cls.fr

https://igsac-cnes.cls.fr

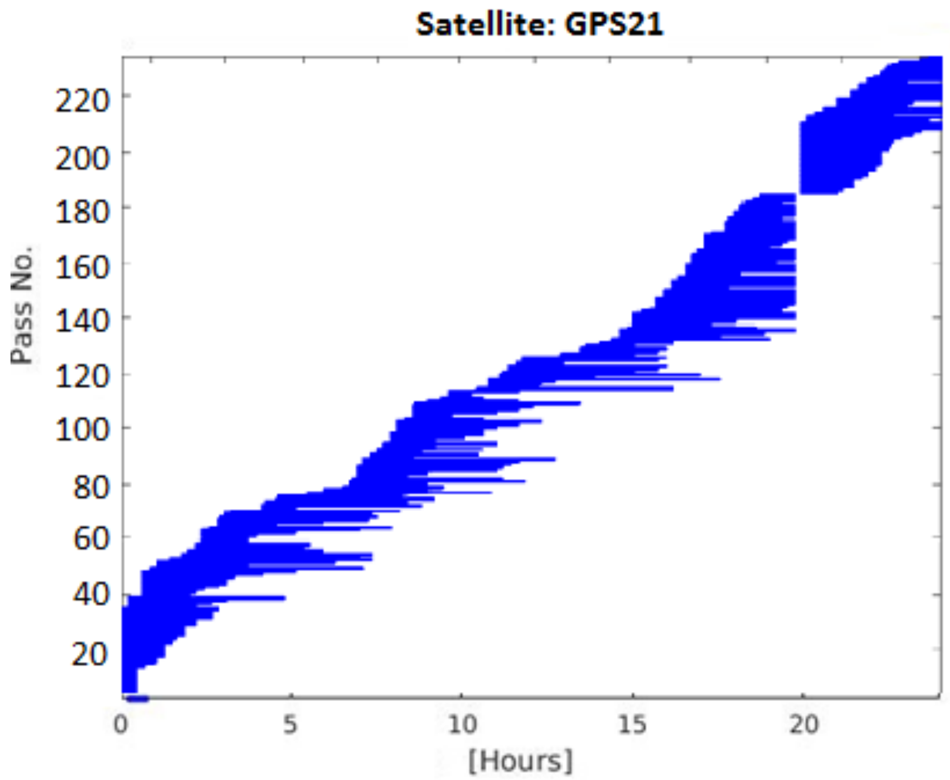
References

[slide 2] https://geodesy.science/item/gnss-orbits-clocks/ (icon)
[slide 2] https://fr.pinterest.com/pin/algorithm-free-vector-icons-designed-by-linector--343118065366895487/ (icon)
[slide 6&7] https://photolibrary.esa.int/home-page/ (satellite icon)
[slide 7] Rubik's cubes generated by AI
[slide 13] https://commons.wikimedia.org/wiki/File:World_map_geographical.jpg (image)

BACKUP SLIDES



Station: OUS2
Pass No.
[Hours]



Satellite: GPS21
Pass No.
[Hours]