Consierations about arc-length in GNSS processing

R. Dach, T. Springer, A. Sibthorpe
based on contributions from the satellite geodesy research group at AIUB

Chairs of the session on Orbit Modelling

IGS AC Workshop
15–17. April 2019, Potsdam, Germany

Overview

Why longer arcs?

Benefits and issues for orbit products

Benefits for ERP products

Strategies for long–arc solutions

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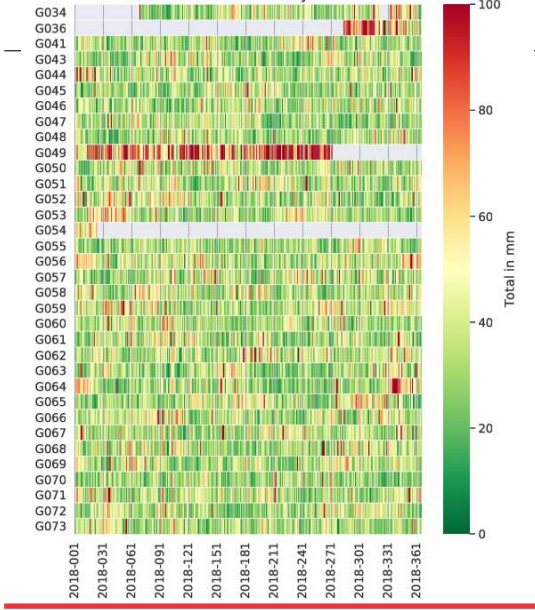
- improve the quality of Earth rotation parameters.

Currently we have the following approaches in the IGS:

- clean daily solutions with 24 hours orbit arcs
- 24 hour solutions with continuity conditions
- solutions with arcs over 30/36 hours
- three-day long-arc solutions with orbit arcs over 72 hours


Orbit misclosures: 1-day solution
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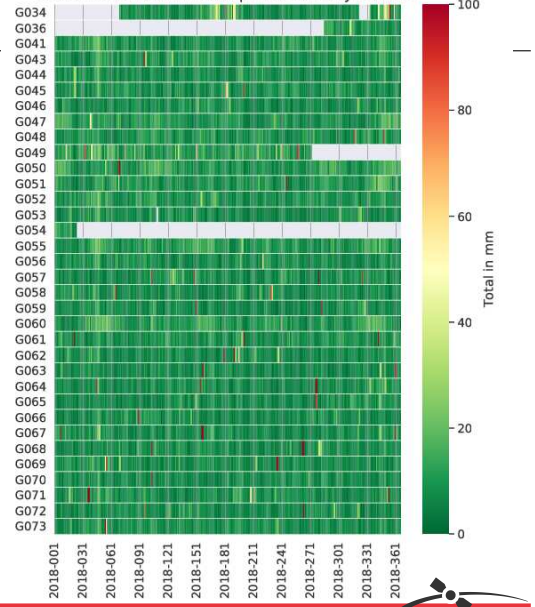
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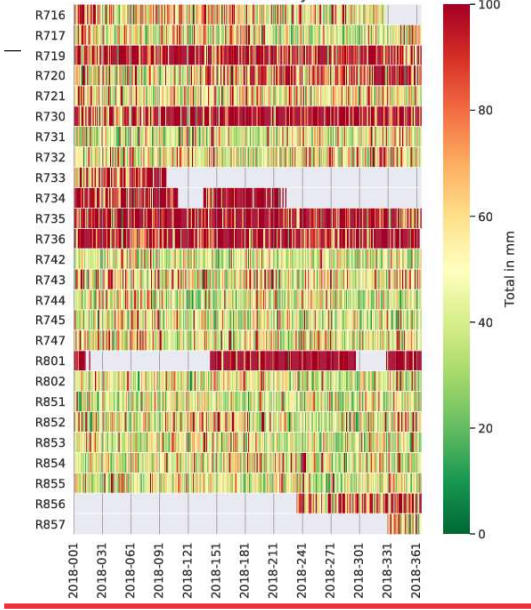
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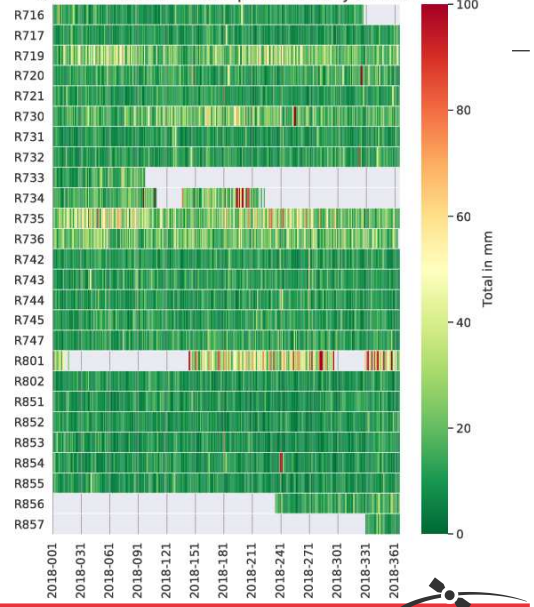
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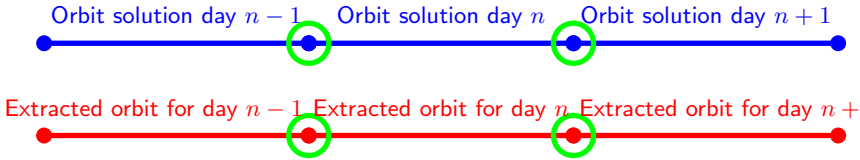

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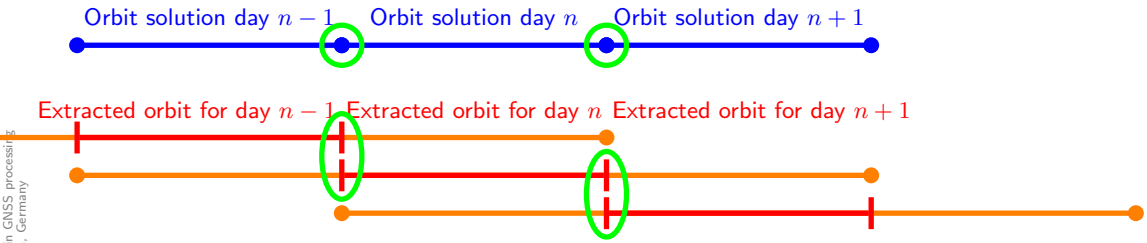

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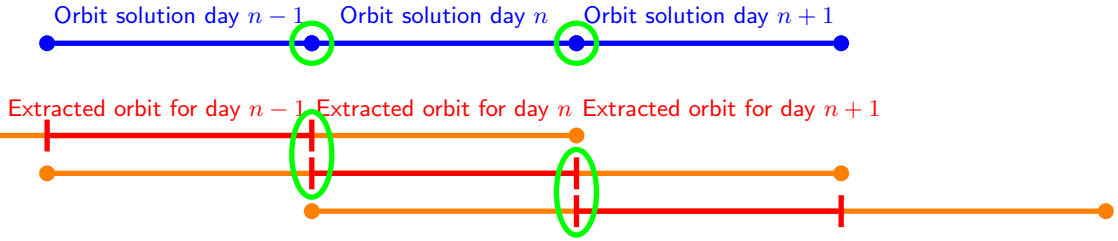
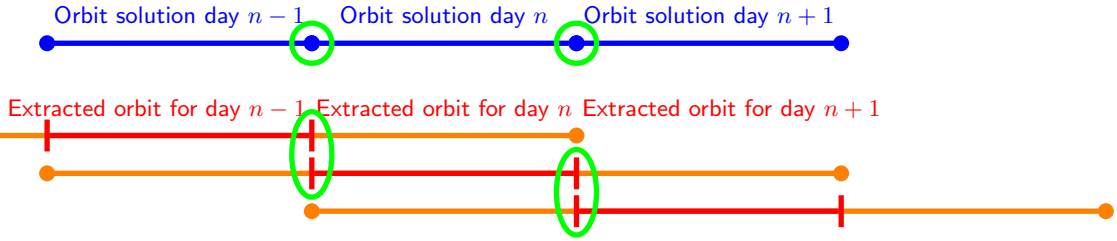


Disadvantage of the "Extracted orbit for day n" with respect to the direct "Orbit solution day n":

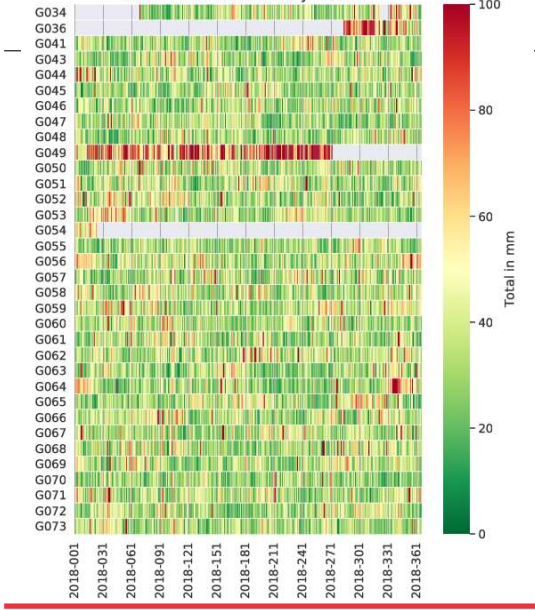
- The orbits extracted from the three-day arc are not independent anymore.
- Day boundary discontinuities cannot be used as a real quality indicator anymore.

Orbit misclosures



Disadvantage of the "Extracted orbit for day n" with respect to the direct "Orbit solution day n":

- The orbits extracted from the three-day arc are not independent anymore.
- Day boundary discontinuities cannot be used as a real quality indicator anymore.
- A comparison at the end of the long arcs is more appropriate as a quality measure.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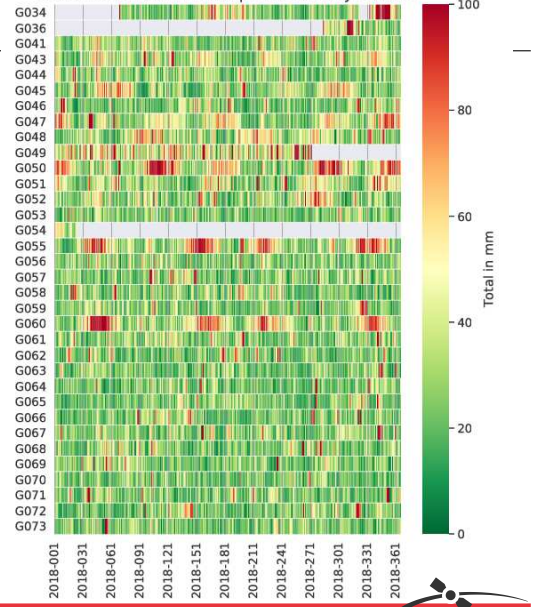
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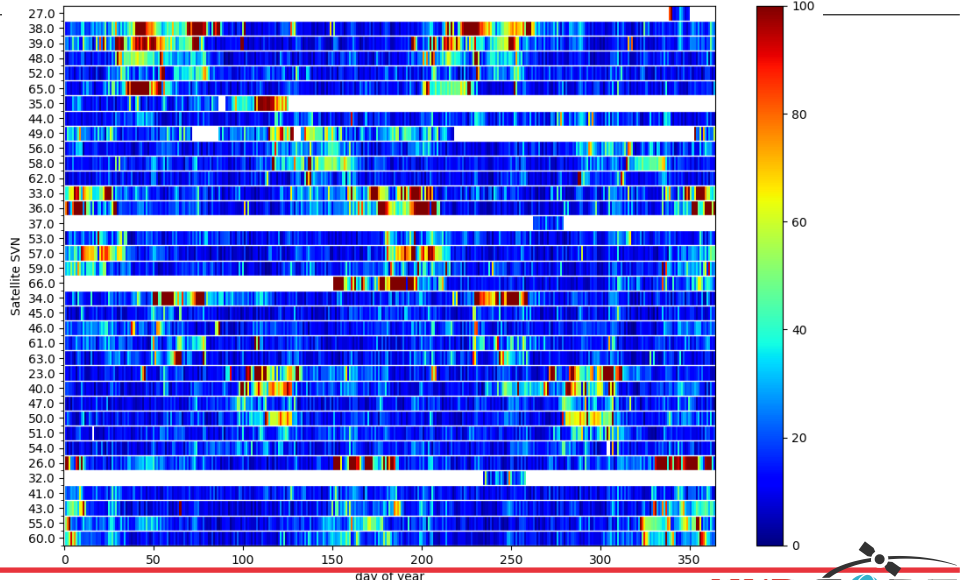
Orbit Overlaps for GPS in 2013 (d: no pulses)



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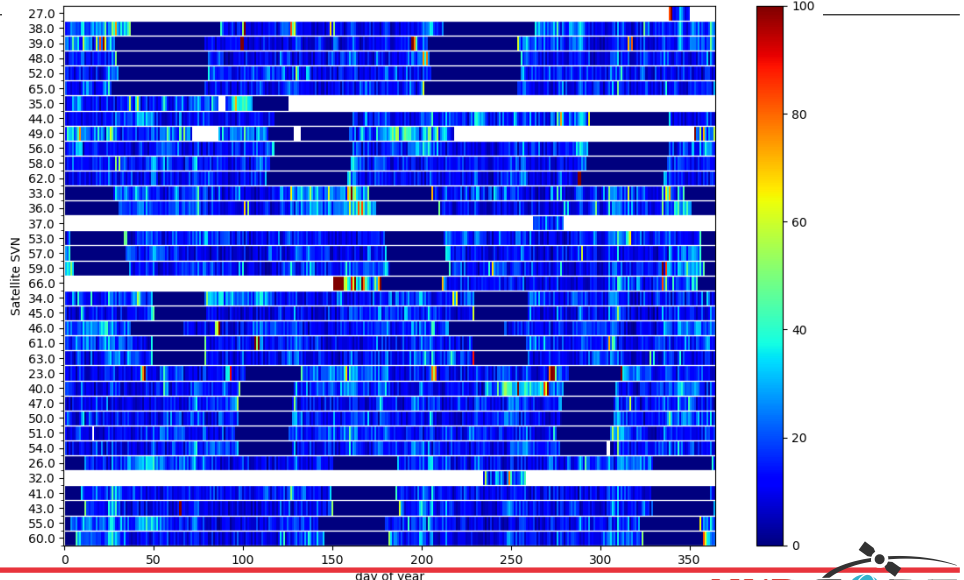
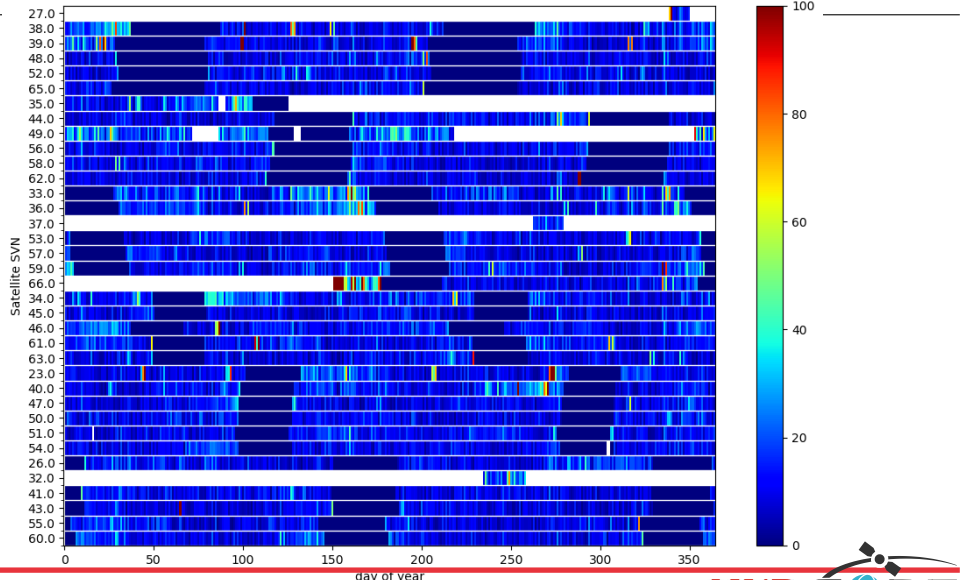


Orbit Overlaps for GPS in 2013 (s: Pulses only in the middle of eclipse)



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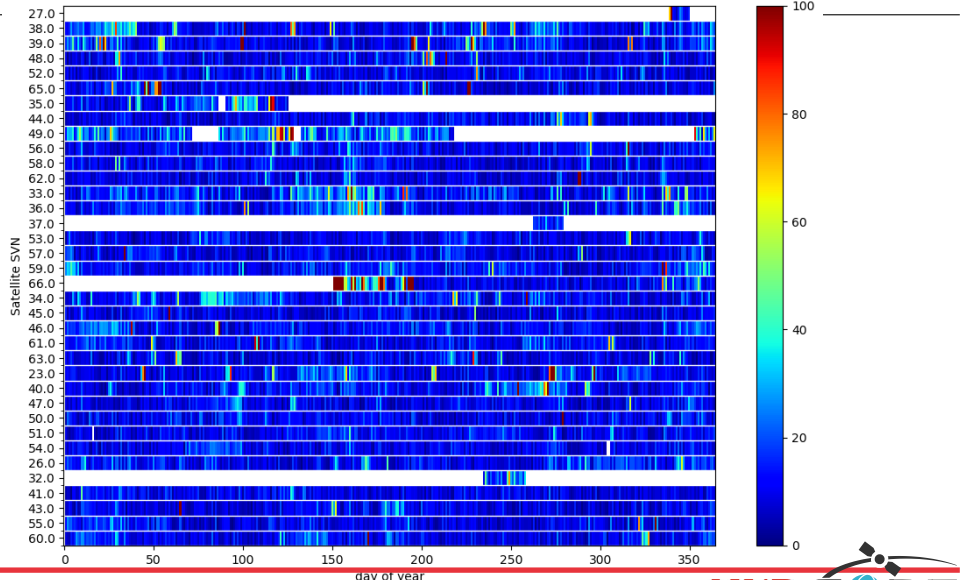
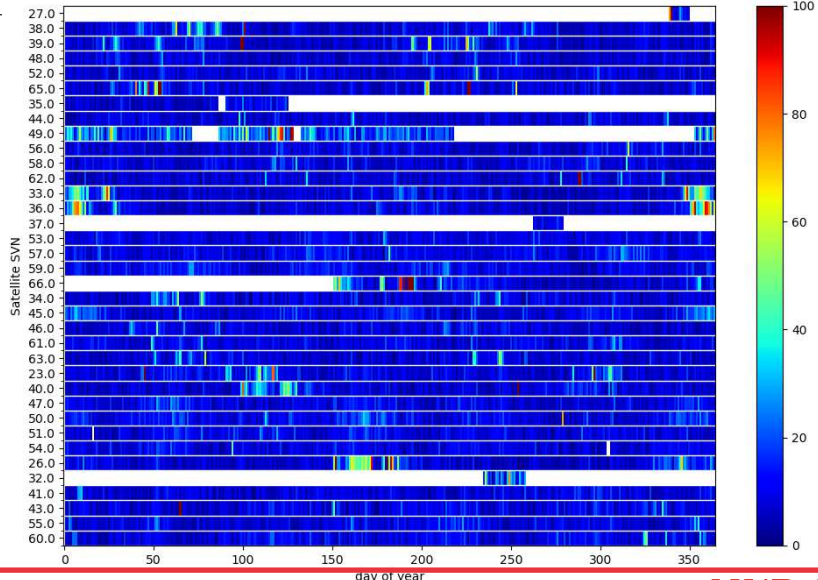
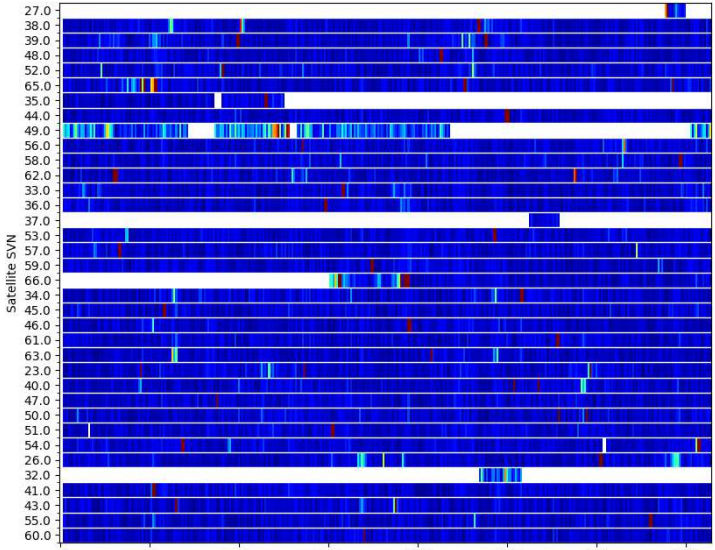


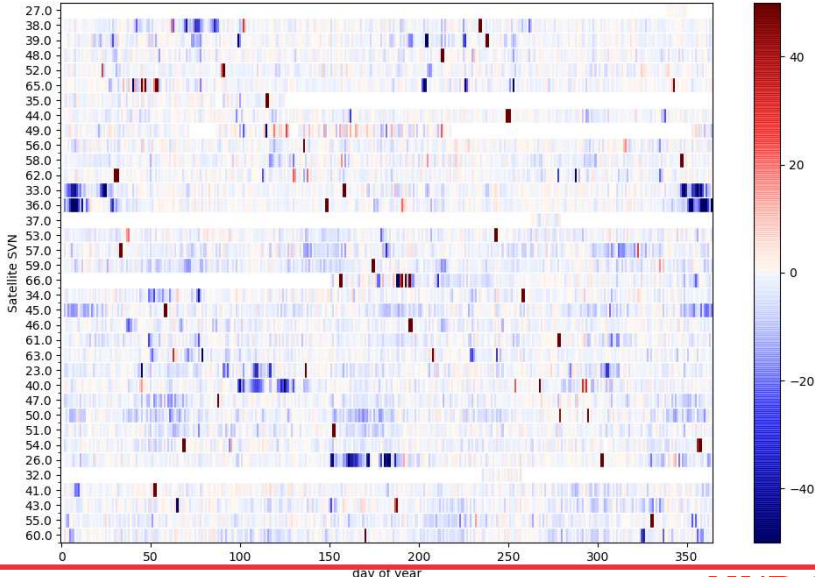
Orbit Overlaps for GPS in 2013 (p: Pulses every 12 hours)



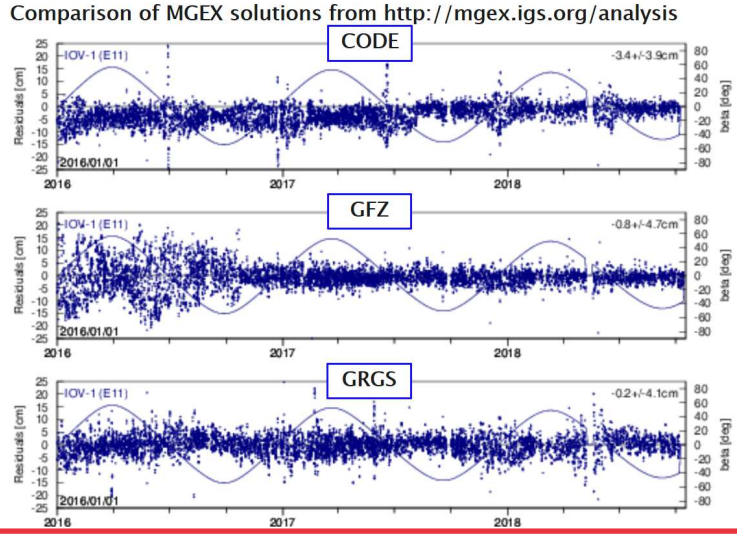
Orbit Overlaps for GPS in 2013 (u: Pulses at orbit midnight)



Orbit Overlaps for GPS in 2013 (u−p: blue means u is better than p)



SLR residuals for SVN 101



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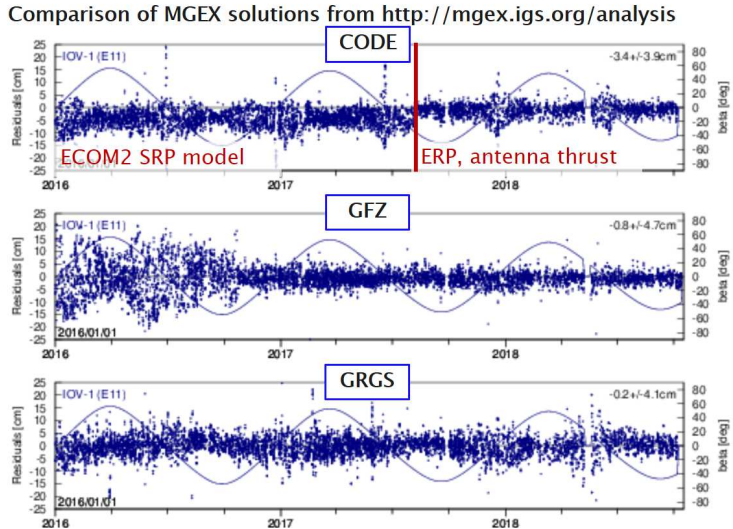

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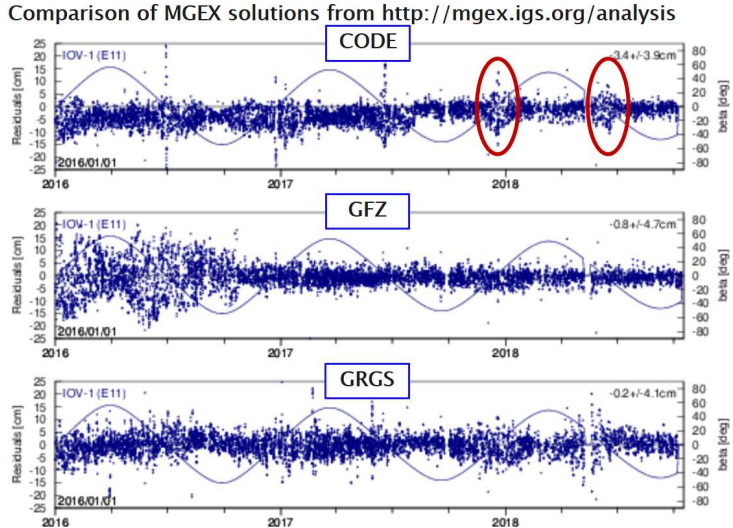

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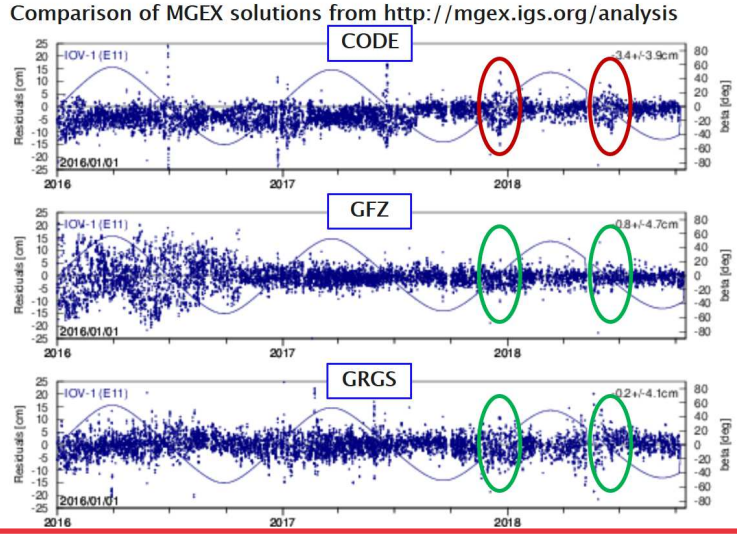

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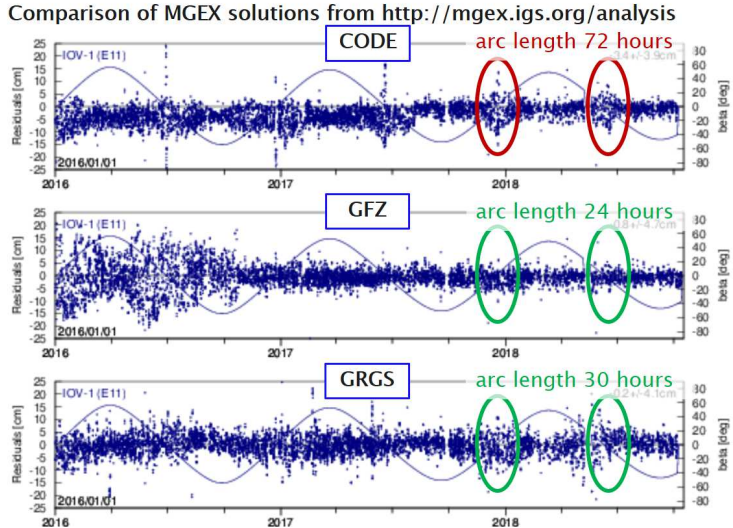
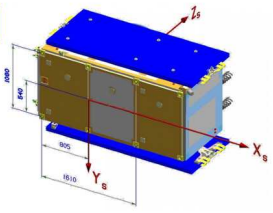


Orbit model extension

IOV

FOC



Galileo satellites (Galileo Satellite Metadata, URL: https://www.gsceuropa.eu).

Radiators are installed on

- IOV satellites: +X, +Y, −Y
- FOC satellites: +X, +Y, −Y and −Z

D. Sidorov, R. Dach, L. Prange, A. Jäggi: **Improved orbit modelling of Galileo satellites during eclipse seasons.** Presented at IGS workshop, Wuhan, China, 29 Oct. – 02 Nov. 2018.

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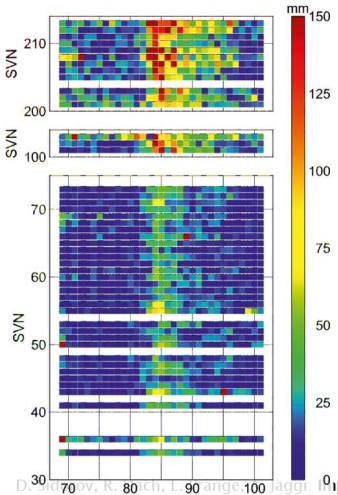
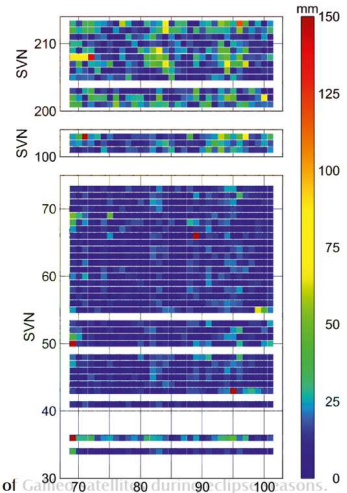




D. Arnold, R. Dach, L. Lange, J. Sušnik, A. Jäggi: Improved orbit modelling of Galileo satellites during eclipse seasons. Presented at IGS AC Workshop, Wuhan, China, 29 Oct. – 02 Nov. 2018.

GNSS orbits and ERPs from CODE's repro2 solutions

S. Lutz[1], P. Steigenberger[2], G. Beutler[1],
S. Schaer[3], R. Dach[1], A. Jäggi[1]

[1] Astronomical Institute of the University of Bern, Bern, Switzerland
[2] Technische Universität München, Munich, Germany
[3] Federal Office of Topography swisstopo, Wabern, Switzerland

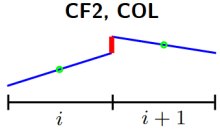
IGS Workshop
June 23–27, 2014
Pasadena (USA)

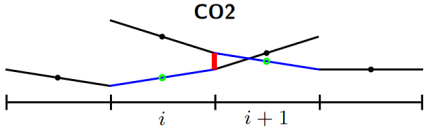
Consequences on ERPs

- Analysis of the pole misclosures

$$
\begin{aligned}
Xm_{i,i+1} &= \left(X_{i+1} - \frac{Xrt_{i+1}}{2}\right) - \left(X_i + \frac{Xrt_i}{2}\right) \\
Ym_{i,i+1} &= \left(Y_{i+1} - \frac{Yrt_{i+1}}{2}\right) - \left(Y_i + \frac{Yrt_i}{2}\right)
\end{aligned}
$$

$Xm_{i,i+1}$, $Ym_{i,i+1}$	Misclosure of X and Y pole between day i and $i+1$
X_i, Y_i	Polar motion in X and Y at 12 UTC on day i
Xrt_i, Yrt_i	Polar motion rate per day in X and Y for day i





- Analysis of the formal a posteriori errors

Consequences on ERPs

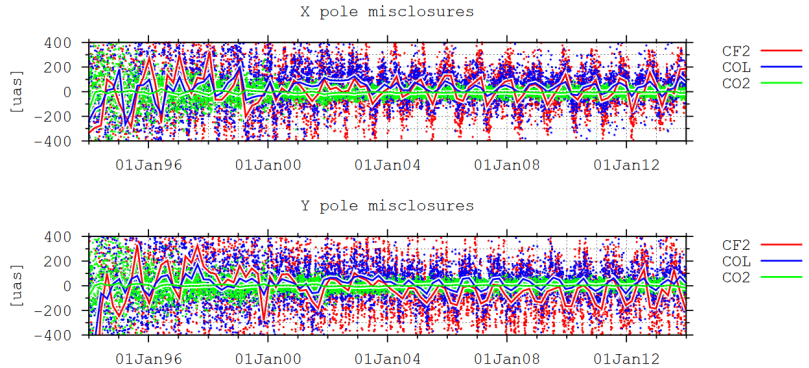
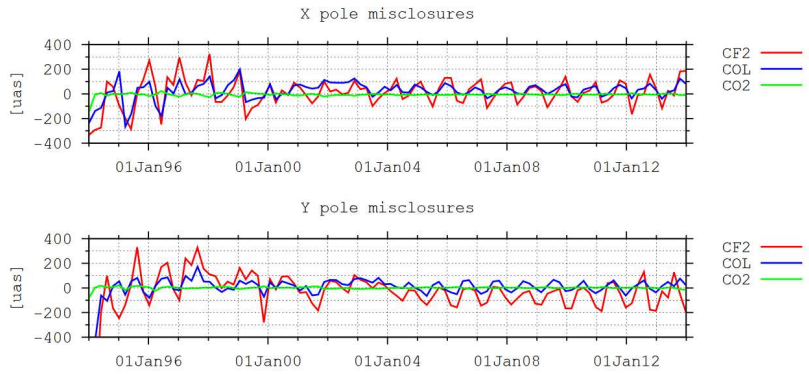


Figure 4 Time series and Bézier curves of the pole misclosures. There is almost no variation in the CO2 solution after Jan-2000. Low frequency periods in CF2 and COL are obvious.

Consequences on ERPs



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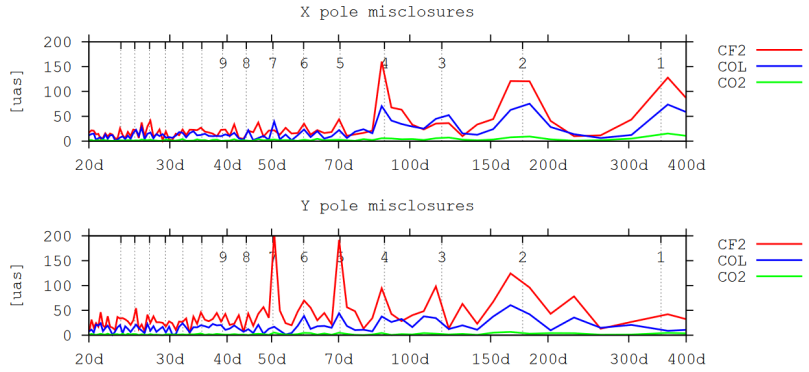

Figure 5 Spectra of the pole misclosures *between Jan-1997 and Dec-2001* (**GPS-only**). Signatures in the CF2 solution are considerably reduced in the COL and nonexistent in the CO2 solution.

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Consequences on ERPs

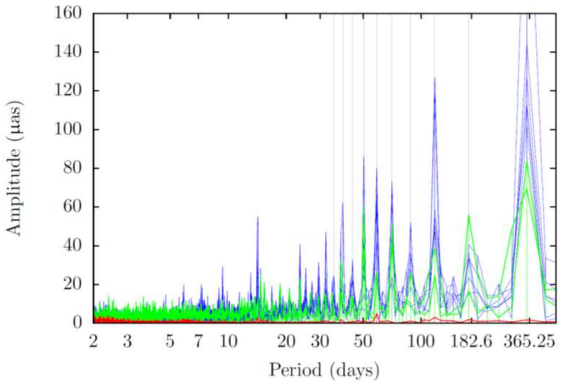
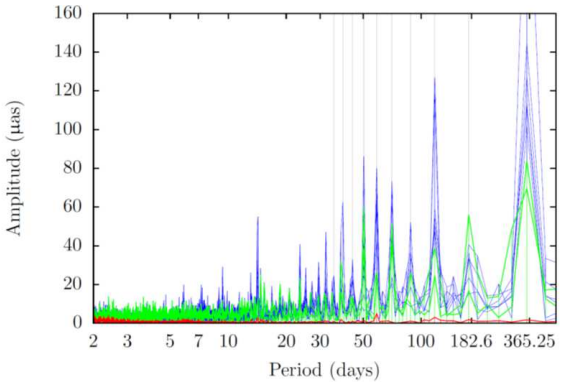


Fig. 1 Amplitude spectra of y-pole coordinate misclosures from REPRO-2 series in 2009–2013 for six 1-day solutions (blue), two 30-hour solutions (green), and a 3-day solution

Consequences on ERPs



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Longer arcs are beneficial for estimating ERPs (in particular for the rates).

Consequences on GCCs

From Lutz et al.: *Impact of the arc length on GNSS analysis results*

Table 2: Effect of the arc length on the RMS of the geocenter series 2009–2011

Component	GPS (1-day)	GLO (1-day)	GPS (3-day)	GLO (3-day)
X	13 mm	8 mm	9 mm	6 mm
Y	10 mm	11 mm	8 mm	7 mm
Z	103 mm	12 mm	95 mm	9 mm

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Longer arcs are beneficial for GCC estimates as well.

Benefits from long-arc solutions

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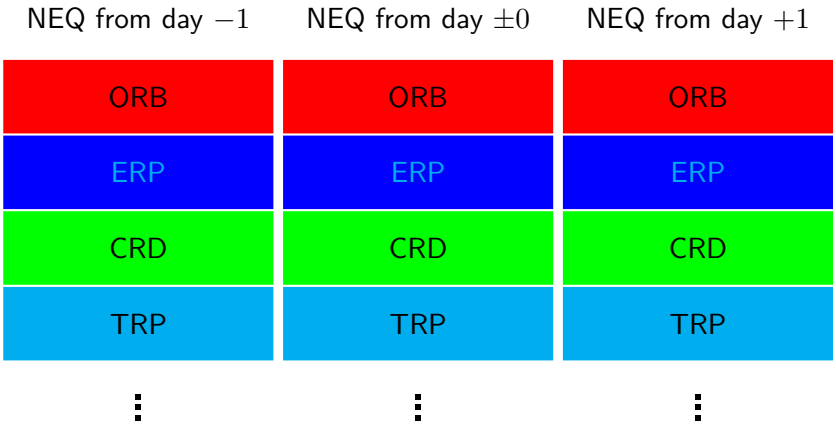
How to realize long-arc solutions?

Strategies for long–arc solutions

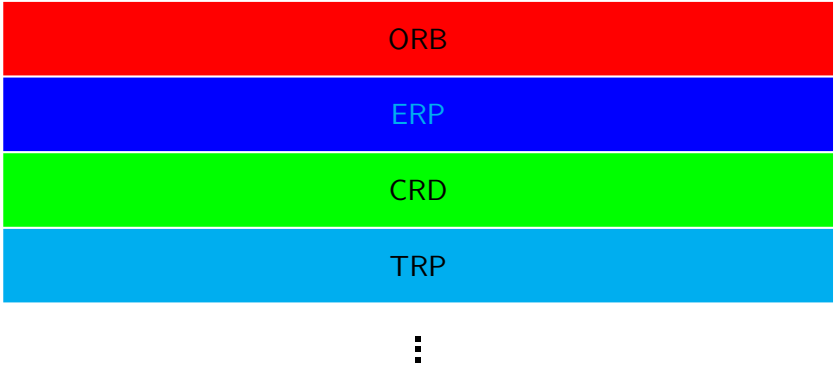
Approach to generate three–day solutions at CODE:



Strategies for long–arc solutions

Approach to generate three–day solutions at CODE:

NEQ for long–arc solution, day ± 0



Strategies for long–arc solutions

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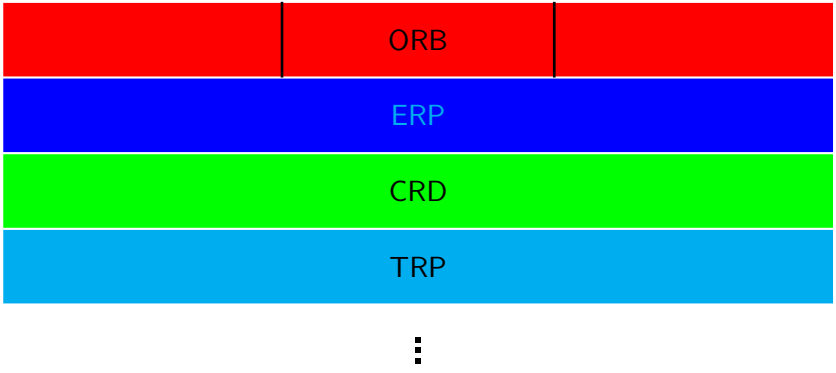

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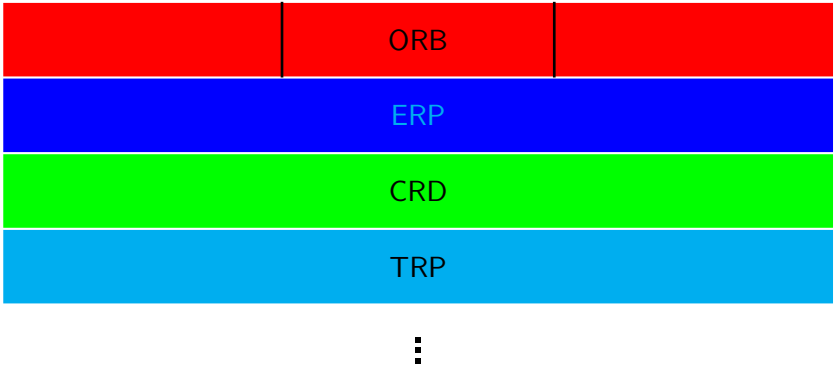

Compatibility?

ATM-loading?

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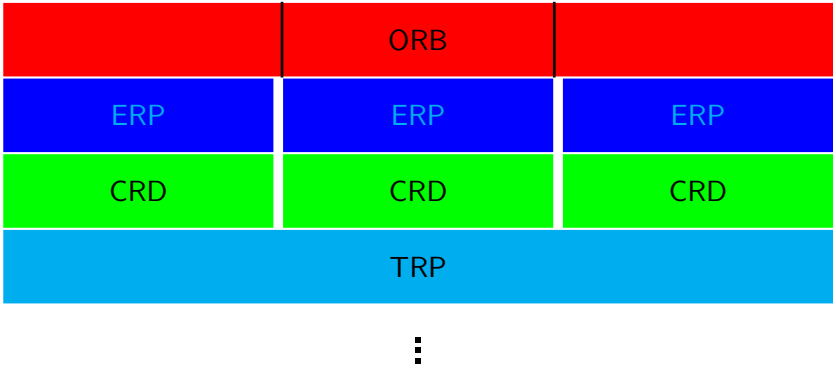

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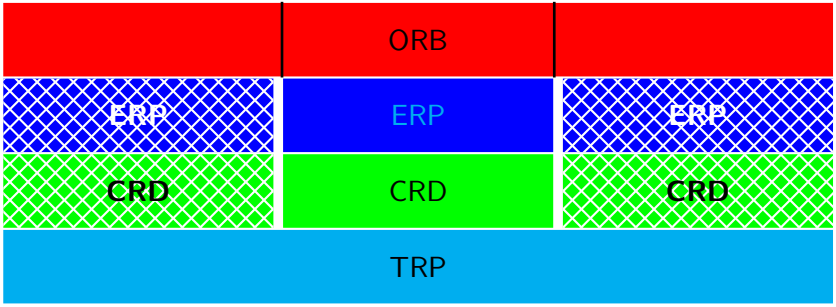

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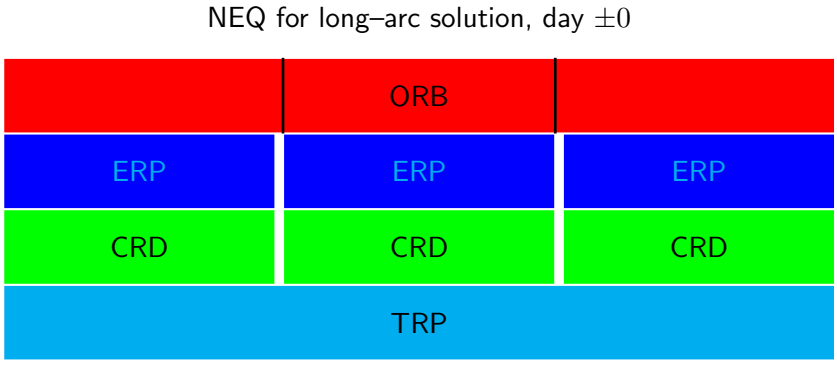

Clean one-day or long-arc solutions

Clean one-day solution:

Long-arc solution:

Clean one-day or long-arc solutions

Clean one-day solution:

- Allows the interpretation of results because each daily solution is completely independent.
- Discontinuities can be used as quality measure.

Long-arc solution:

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- More flexible usage of the products (also outside from the daily processing scheme).

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- Allows the interpretation of results because each daily solution is completely independent.
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Long-arc solution:

- More flexible usage of the products (also outside from the daily processing scheme).
- Better suited for the general usage.

Clean one-day or long-arc solutions

Clean one-day solution:

- Allows the interpretation of results because each daily solution is completely independent.
- Discontinuities can be used as quality measure.
- Primary for scientific usage.
- No exception for none of the contributions can be allowed.

Long-arc solution:

- More flexible usage of the products (also outside from the daily processing scheme).
- Better suited for the general usage.
- Each AC contributes with the optimal arc-length according to its capabilities.