Status of the ILRS support for the Grace-FO mission

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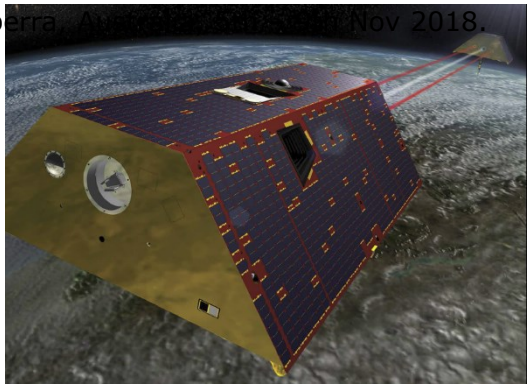
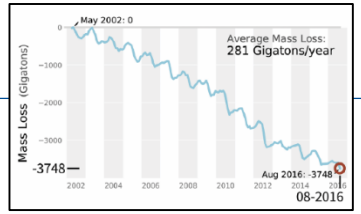
Grace-FO mission

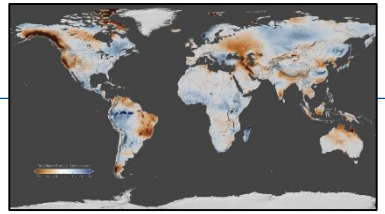


- After 15 years of GRACE we have a successor
  - Continuation of the data collection for at least 5 years
  - Launched on May 22nd 2018 into a 491 km polar orbit
  - Two spacecraft with a separation distance of approx. 220 km
- Prime measurement: spacecraft separation distance change
  - Baseline: K-Band microwave, Technology Demonstrator: Laser Ranging Interferometer
  - From this data monthly gravity field solutions are derived
- The time series over 15 years enables e.g. the following science

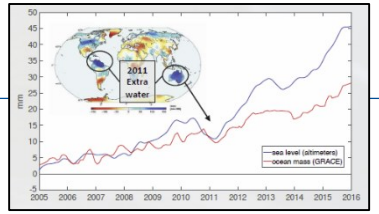
Melting of ice sheets (e.g. Greenland).



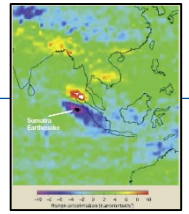
Ground water storage change.



Seawater level rise.



Solid Earth changes (e.g. Earth quakes).



Mission status

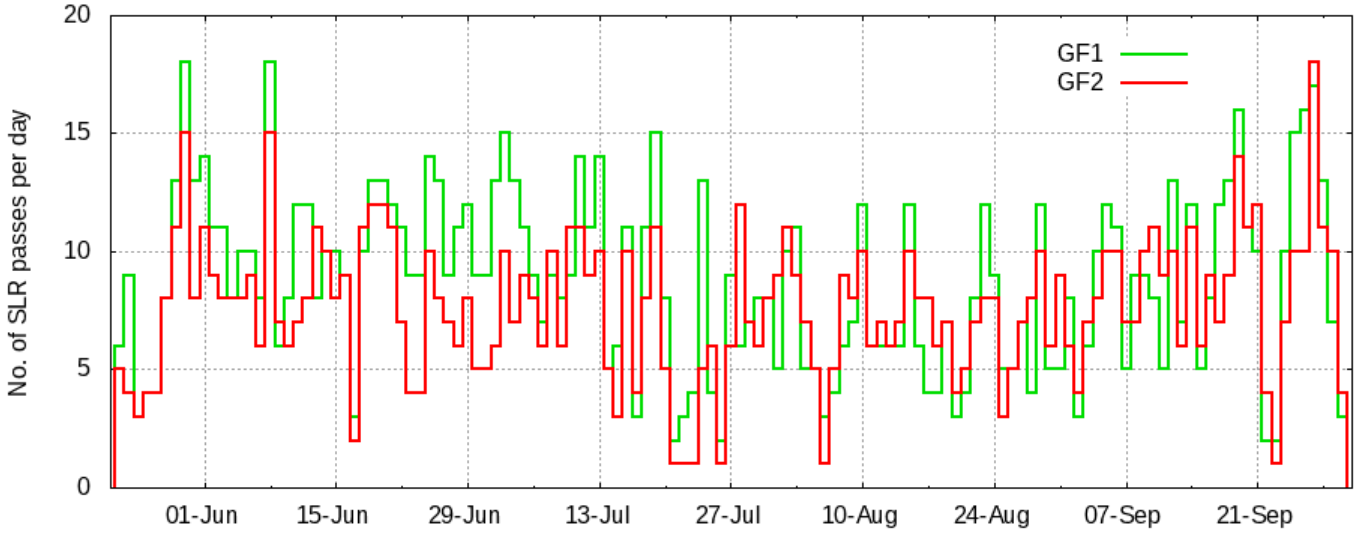
- Initial checkouts (separation, switch-on of instruments) during 4 days LEOP, after that begin of the IOC phase
- IPU failure on GFO2 on July 19th, no explanation so far
  - No GPS data available on GFO2 since IPU is a part of the GPS system
- Successful switch to redundant GFO2 IPU on October 16th
  - Nominal baseline mission data flow (GPS, KBR, SCA, ACC) continued since October 22
  - LRI still off (initial tests showed that it worked extremely well)
- Science phase from ≈ Mid January on, until then IOC phase
  - Finalizing calibration maneuvers, several AOCS tests to improve ACC performance
  - In Science Phase first at least 60 days of calibrated KBR data will be acquired as baseline for gravity field determination within the SDS, then operational phase starts

SLR support for the Grace-FO mission

- POD from SLR data for GFO1 and GFO2
  - Calibration and monitoring of GPS receivers as well as redundant spacecraft positioning
- After IPU failure, SLR provided the positioning for GFO2
- Interesting situation for a quality comparison
  - GFO1 POD and orbit predictions: from GPS data
  - GFO2 POD and orbit predictions: from SLR data
- SLR orbit prediction accuracy requirement is a time bias < 10 ms
- As GPS, the SLR based orbit predictions achieved that

SLR tracking data statistics

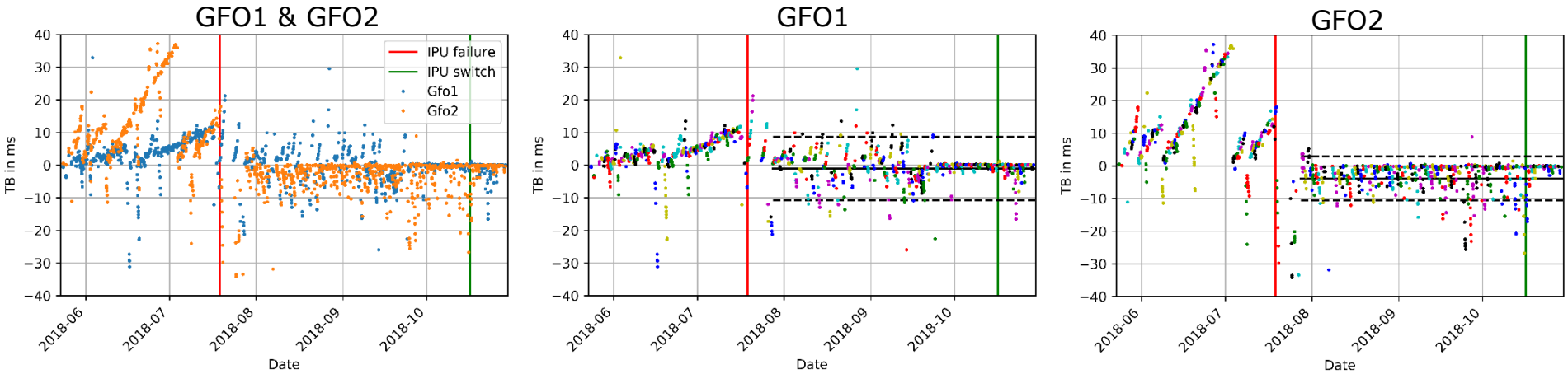
- 1st SLR passes on May 23rd: GFO1 1873, GFO2 & Tandem 7841
- Continuous coverage except for outliers and after IPU failure
- SLR based POD requires ≈> 5 passes per day, mostly fulfilled



Coverage of SLR passes for GFO1 and GFO2.

GPS & SLR orbit prediction quality

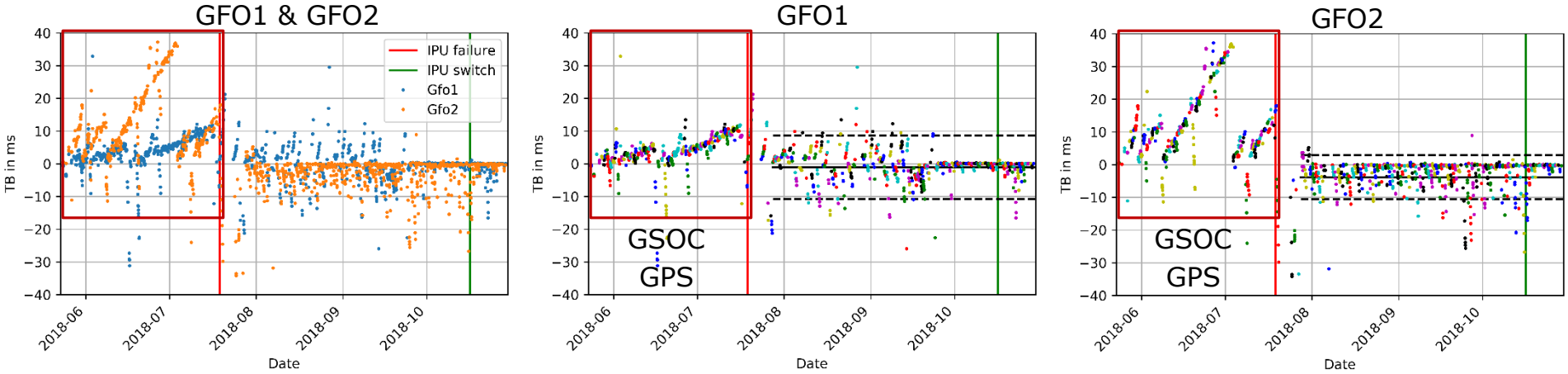
- GFO SLR orbit predictions are provided by GFZ



GFO1 and 2 time bias value comparison. Combined for both in the left and colored by prediction for GFO1 in the middle and for GFO2 in the right figure. Mean value is highlighted by solid black line and the standard deviation (Std) by the dashed black line.

GPS & SLR orbit prediction quality

- GFO SLR orbit predictions are provided by GFZ
- Before IPU failure orbits were based on GSOC GPS Nav solutions
- IPUs had time drift (GFO2>GFO1) bias removal with every reset



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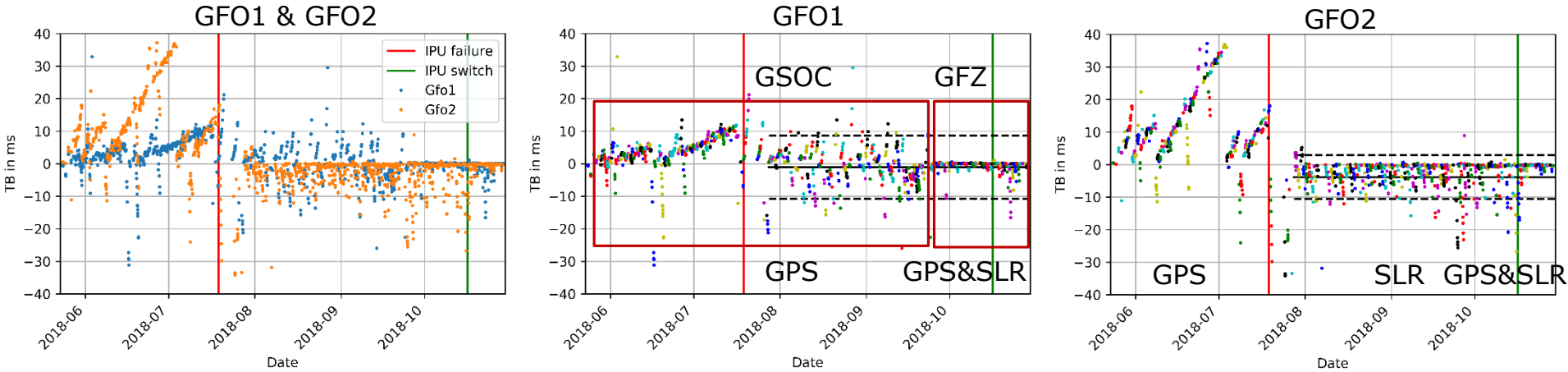
GPS & SLR orbit prediction quality

- After IPU failure, the orbit predictions were still based on GPS data for GFO1
- Complete calculation by GFZ improved time biases



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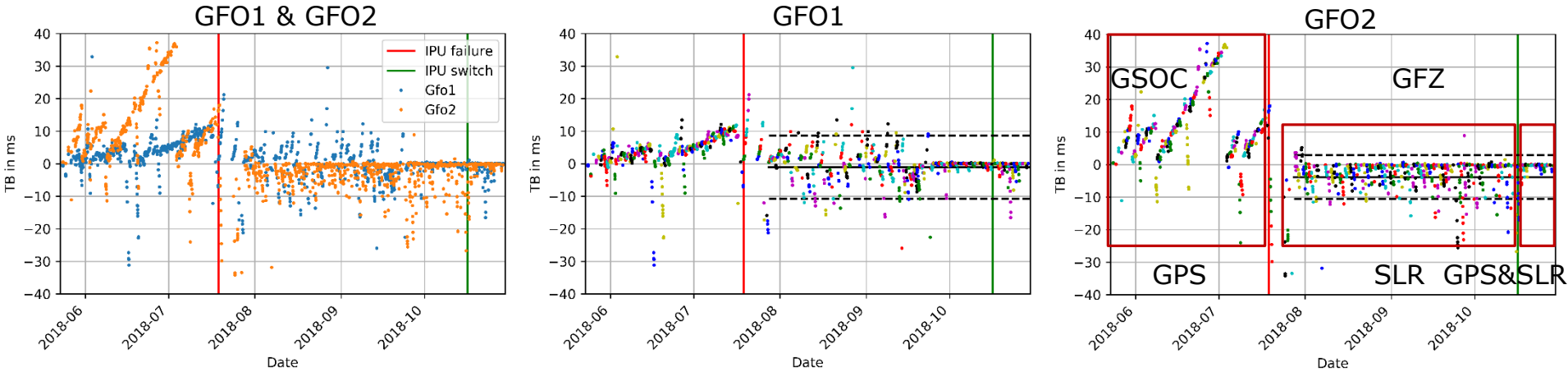
GPS & SLR orbit prediction quality

- After IPU failure, the orbit predictions were still based on GPS data for GFO1 but on SLR data for GFO2
- Complete calculation by GFZ improved time biases



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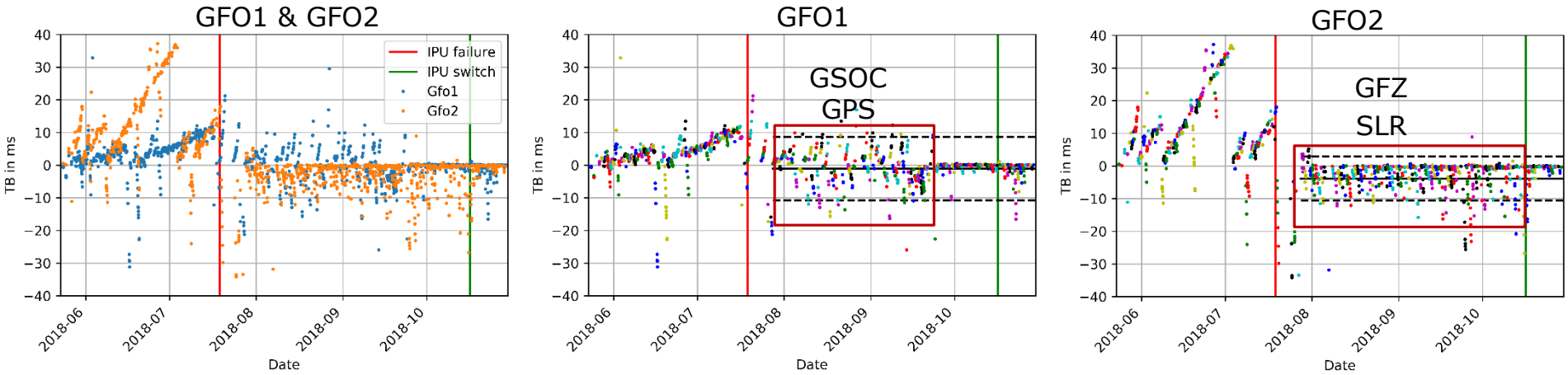
GPS & SLR orbit prediction quality

- Time bias variation (Std) of GFO2 SLR only < GFO1 GSOC GPS
- SLR only orbit predictions fulfilled 10 ms time bias requirement



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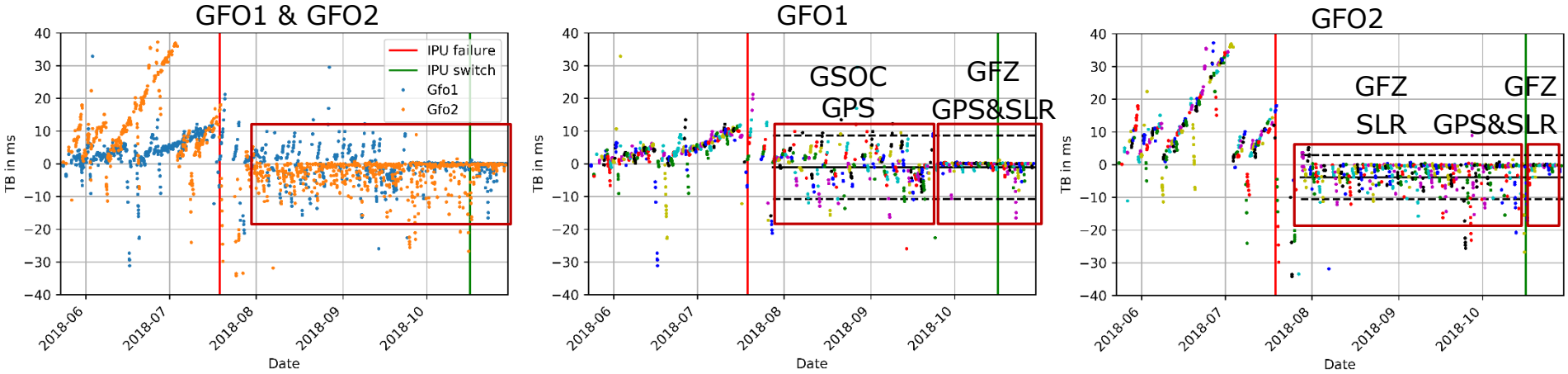
GPS & SLR orbit prediction quality

- Time bias variation (Std) of GFO2 SLR only < GFO1 GSOC GPS
- SLR only orbit predictions fulfilled 10 ms time bias requirement
- Finally GPS&SLR GFZ orbit predictions are best for GFO1 & GFO2



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Summary

- The GFO climate research mission is in orbit since May 22nd
- ILRS stations provide SLR data for calibration, validation and monitoring of the GPS based SC positioning and for redundancy
- After the IPU failure (July 19th – October 16th 2018) the GFZ orbit predictions for GFO2 were done with SLR data only
- SLR only orbit predictions fulfilled the SLR accuracy requirement saying that the time bias shall be smaller than 10 ms
- Successful change to the redundant GFO2 IPU on Oct 17th 2018
- Science phase will start in mid January 2019 approximately

Thank you for your attention!