IGMA-IGS Joint Trial Project Status Update

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on behalf of the IGS

IGS INTERNATIONAL GNSS SERVICE

IGS-IGMA Main Aims (from terms of reference)

- Make use of the IGS infrastructure and products
  - High quality precise orbit and clocks to be used as reference product for GNSS monitoring
  - Large high quality global tracking station network

- Compute using well defined and documented principles:
  - Orbit and clock differences
    - Allows to easily compute SISRE
  - Signal in space UTC offset error (UTCOE)
  - PDOP and availability
  - Signal in space user range error (SISURE)
    - Using data from the global tracking network

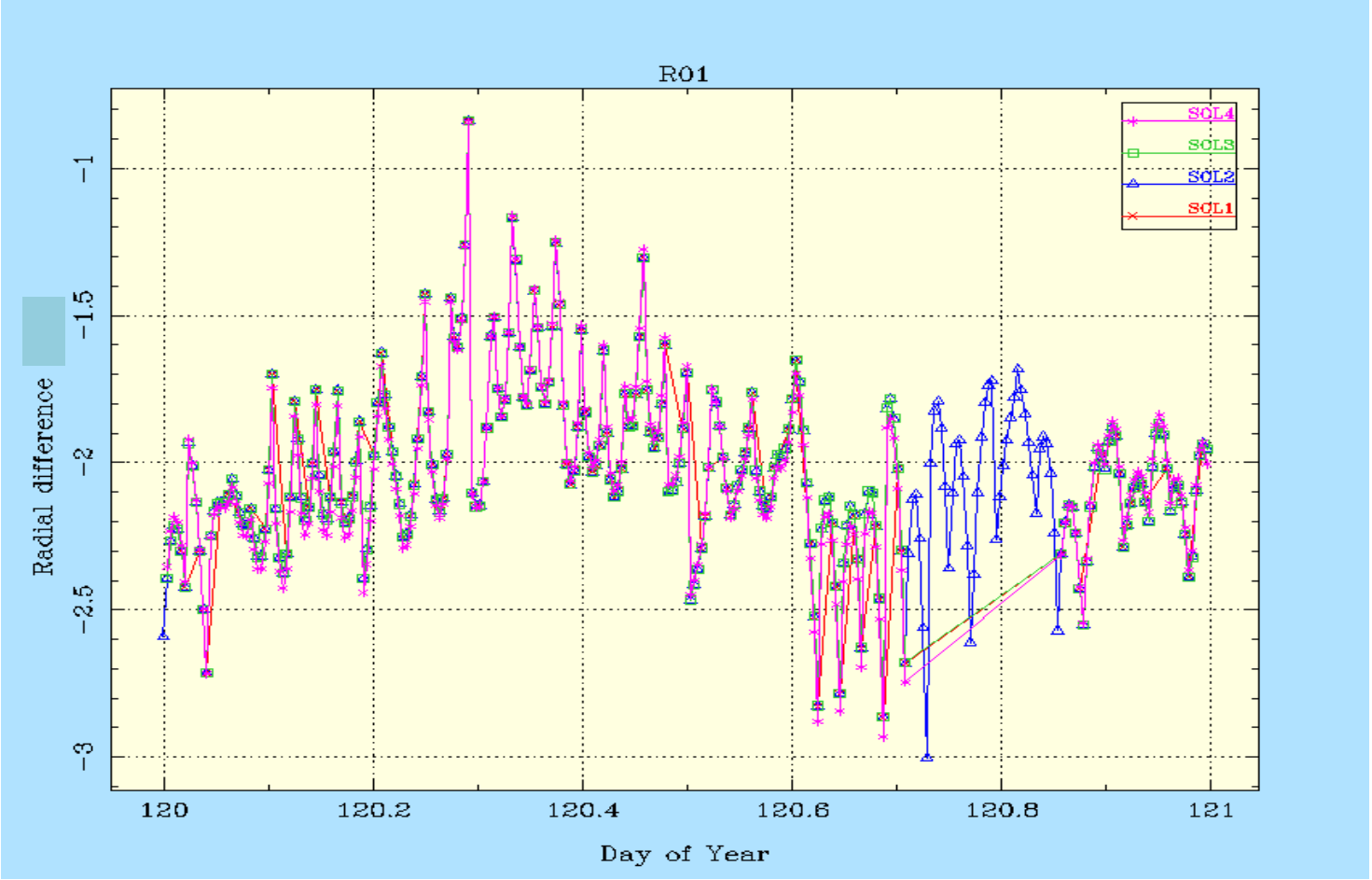
IGS-IGMA joint trial project

- In 2017 12 groups responded to the IGS call for participation
- A smaller subset has been active in this project:
  - DLR, ESOC(lead), GMV, GOP, ICGC, SHAO, UNESP, WHU
- Main Activities
  - 2017-2019 Initial orbit and clock test with vastly different results
    - Resolved this with a number of simpler tests
  - 2019 performed a detailed 1 day test and a 3 month comparison (February to April 2019)
    - Four groups participated in that
- ICG-IGMA comparisons only at “in person” meetings
  - So COVID hindered progress since 2020…..
  - Mainly monthly teleconfs on ICG-IGMA level

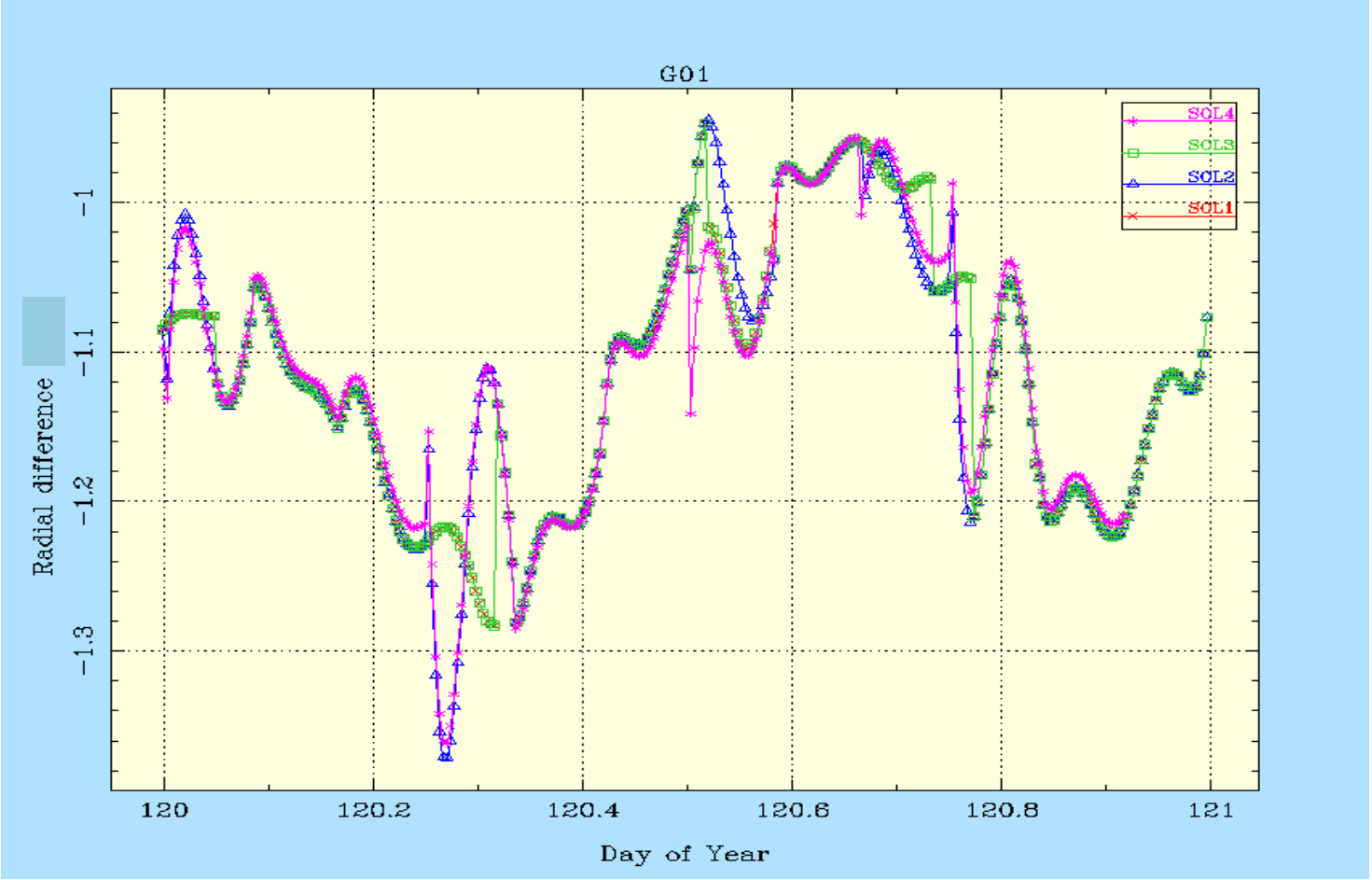
Orbit and Clock Comparison 2019

- The next slides show a couple of results
  - Very controlled experiment
  - All IGS MACs used:
    - Same MGNSS reference orbit
    - Same broadcast orbit file
- Still got significant differences
  - Mostly resolved as being caused by different time intervals used for the different GNSS systems
    - Issues like validity time, start time, end time.
- For the clock comparisons different approaches were used
  - Still discussions needed there
  - Also one approach relies on bias product(s) being available.

GLONASS Differences in very controlled experiment

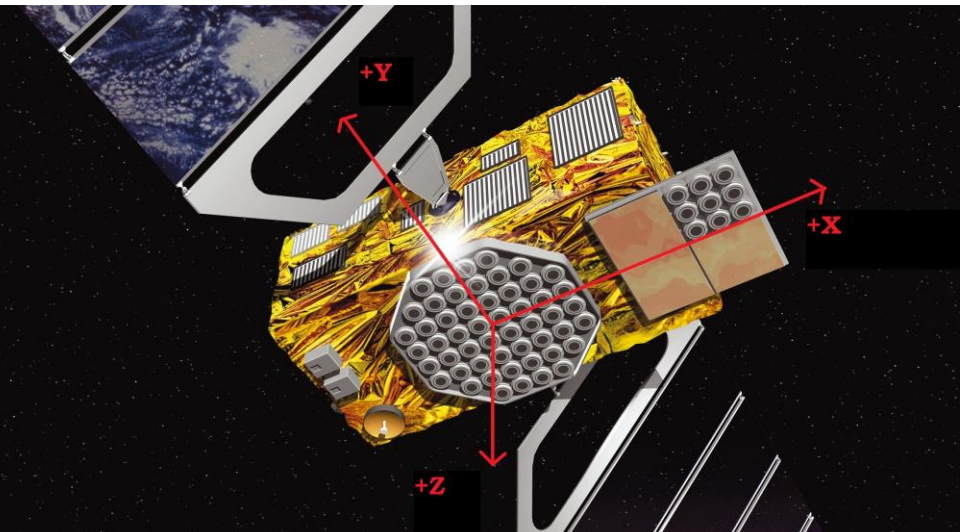


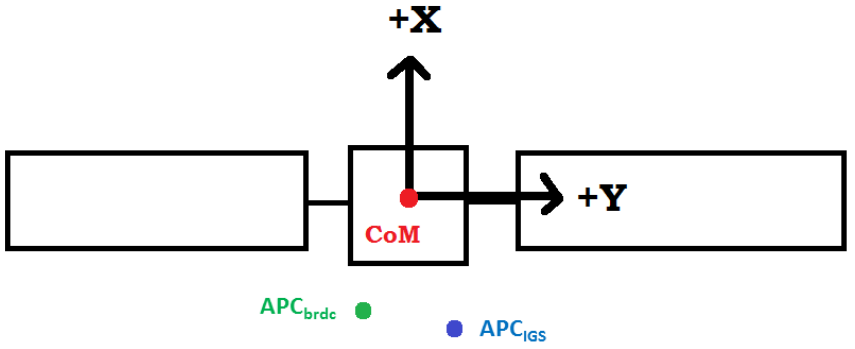
GPS Differences
(driven by validity time differences)



Different Reference Points

- Broadcast orbits and clocks refer to the antenna phase center (APC_{brd})
- IGS Precise orbits refer to the center of mass (CoM) of the satellite
- IGS Precise clocks refer to antenna phase center (APC_{igs})
  - APC_{brd} hardly ever the same as APC_{igs}
- Values (APC_{brd}) have been consolidated





Open Point: Satellite Attitude

- The IGS precise positions have to be transformed
  - From the CoM to the APC_{brd} or visa versa
- The IGS precise satellite clocks have to be transformed
  - From APC_{igs} to APC_{brd} or visa versa or both to CoM
- The X- and Y-offsets ("horizontal") have a limited effect on the clock differences so just accounting for the Z-offset (radial direction) may be sufficient
- Eclipse phases of the GNSS satellites
  - In those phases the satellite rotations are very significant
  - GNSS attitude law for eclipses not known for all systems
  - Not even predictable for some (e.g. switch from Yaw to ON and visa versa)?

IGS-IGMA needs

- IGS-IGMA needs information/activities from IGS:
  - Official IGS combined GNSS orbits and clocks
    - Biases for alignment of clocks for signal differences between precise and broadcast clocks
  - Improved broadcast navigation messages
    - Sometimes get “garbage” in broadcast
    - Or a dedicated product for monitoring purposes
    - Possibly an enhancement of the RINEX Navigation file format (or a new dedicated format)
  - Possibly IGS timescale for UTCOE

- IGS-IGMA needs information/activities from ICG-IGMA:
  - the attitude law of the satellites, in particular during eclipse, that is used for the broadcast ephemerides

Summary

- Orbit differences have converged
- PDOP discussions ongoing in ICG-IGMA
  - does IGS-IGMA want to contribute to that?
- UTCOE to follow after orbit and clock comparison is resolved
- SISURE follows later
  - Computed from network of receivers

- ICG in person meeting October 2022
  - Possibility to compare results
    - A full year of comparisons is planned
  - Time for some renewed activities of IGS-IGMA

Slide courtesy of:
Zhitao Wang,Shuli Song
Shanghai Astronomical Observatory,
Chinese Academy of Sciences
2021-09-15

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PDOP and Availability

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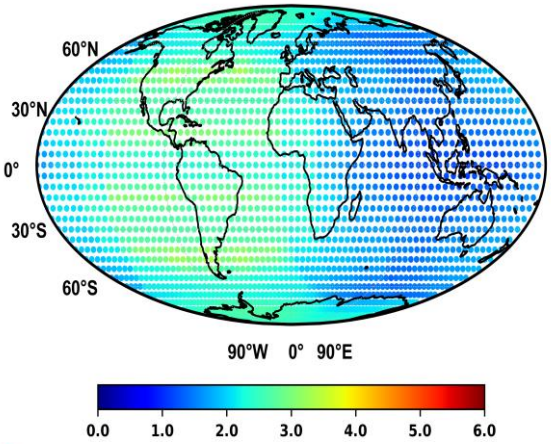

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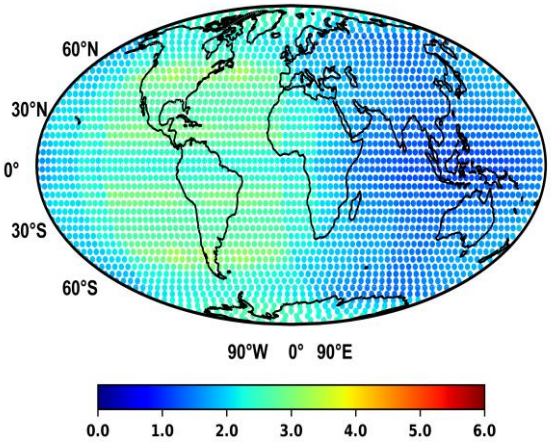

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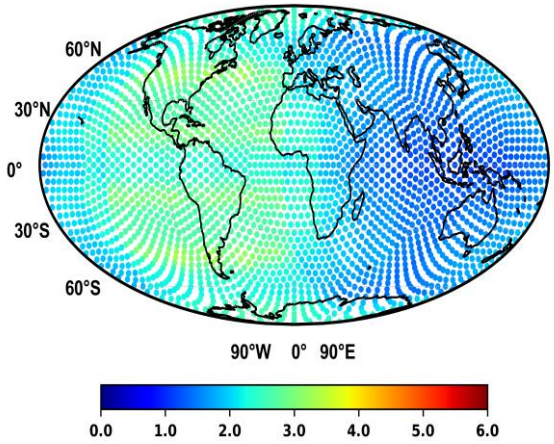

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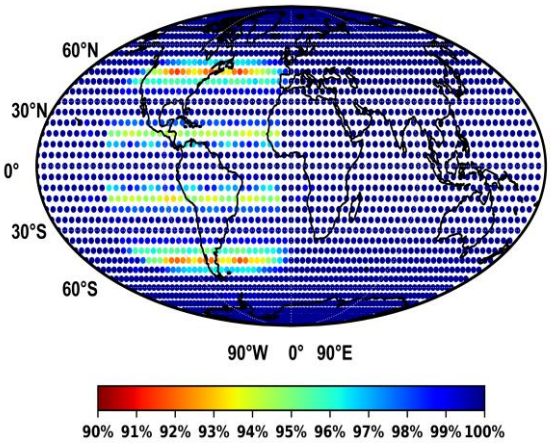

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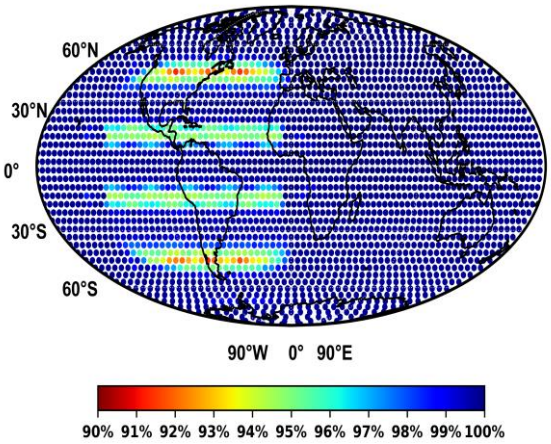

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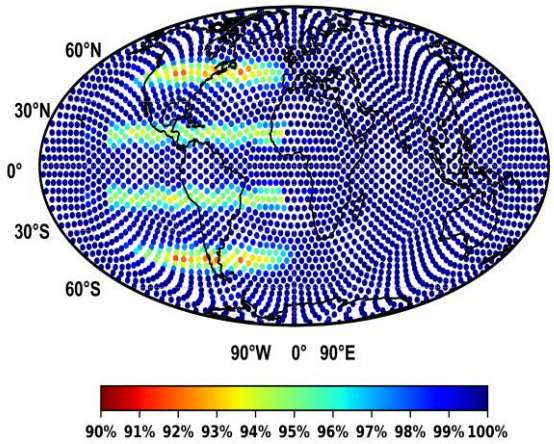

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Next Steps

- Update and review workplan of IGS-IGMA
  - To be done ASAP
- Broadcast Clock monitoring approach
  - Different approaches used, needs some discussion
- Test the reference point conversions
  - So far PCO offsets (both IGS and BRC) were ignored
- Does IGS-IGMA want to contribute to PDOP computations?
- Initial thought on UTC offset error computations
  - Possibility to use IGS Timescale for that?

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The End

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