

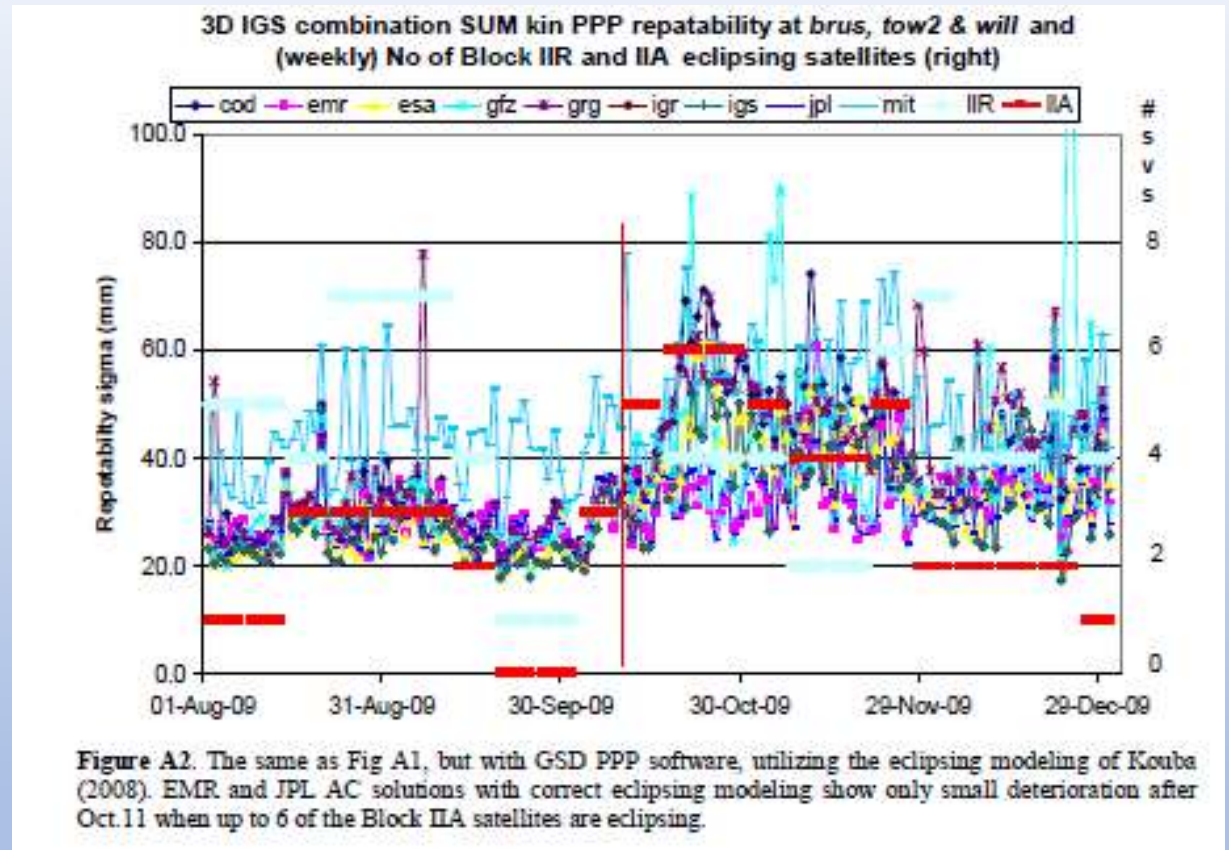
Why attitude is needed for combined products ?

- Attitude differences => yaw angle differences => phase wind up differences => clock estimates differences

$$c \Delta t = \Delta \psi_{yaw} \lambda \quad (\text{seconds})$$

$\lambda = \text{wave length (iono - free, L1, E5, ...)}$

- Due to different attitude models implantation (during eclipses) in the différents s/w used (Acs side and users side)
- Concerns all GNSS satellites during eclipse periods (where the attitude is not well known)
- Old problem for IGS clock combinations
e.g. Kouba 2008/2009 in PPP solutions with different products (and one S/W) →
- Not a problem outside eclipse periods since every s/w use the nominal attitude there.



Exchanging satellite attitude quaternions

To overcome the impossibilities of having the same attitude for all products in all s/w all the time, a proposal was done a few years ago to **exchange attitude information** :

- Format : orbex (only for attitude) using quaternions
- Delivered by analysis centers together with clocks/orbits/biases

Main conclusions up to date:

- (Large) Attitude Inconsistencies between all ACs (GPS/GLONASS) but Good agreement for Galileo
- Clear benefits of using attitude file in clock combinations and PPP/PPP-AR processing (*also presented par J. Geng in the MGEX session, Last Tuesday*)

Campaign Results published in Loyer et al , 2021, Exchanging satellite attitude quaternions for improved GNSS data processing consistency, [Advances in Space Research Volume 68, Issue 6](#)

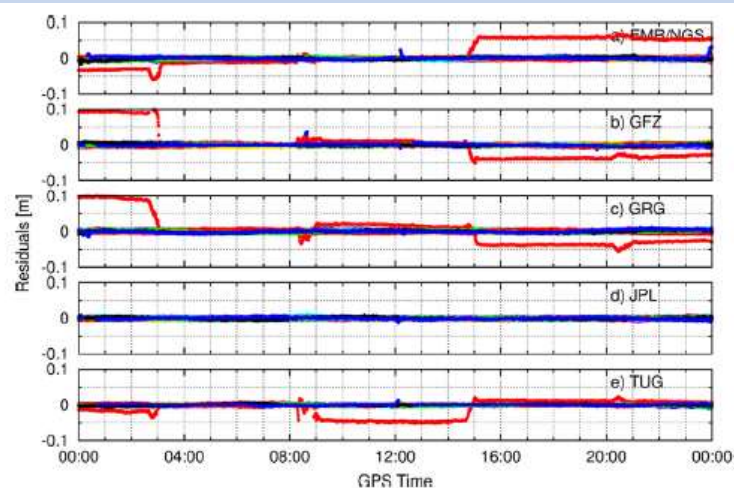


Fig. 6. Satellite clock residuals for the combination of 29 April 2014 without using attitude information.

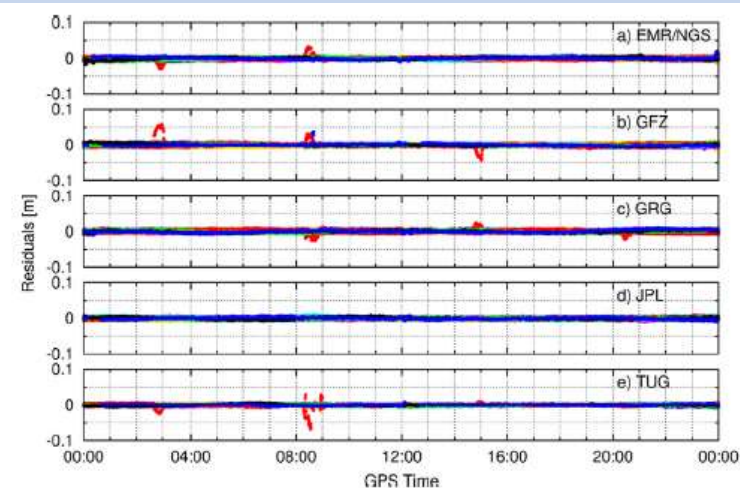


Fig. 7. Satellite clock residuals for the combination of 29 April 2014 when using attitude information provided by analysis centers.

Status of existing Attitude Files within IGS

REPRO3

AC	Orbits/Clocks	Phase biases	Quaternions
COD	GRE	GE	GRE
EMR / NGS	G	G	G
ESA	G	N/A	N/A
GFZ	G	N/A	G
GRG	GRE	GE	GRE
JPL	G	N/A	G
MIT	GE	N/A	N/A
TUG	GRE	GRE	GRE
WHU	GR	N/A	GR

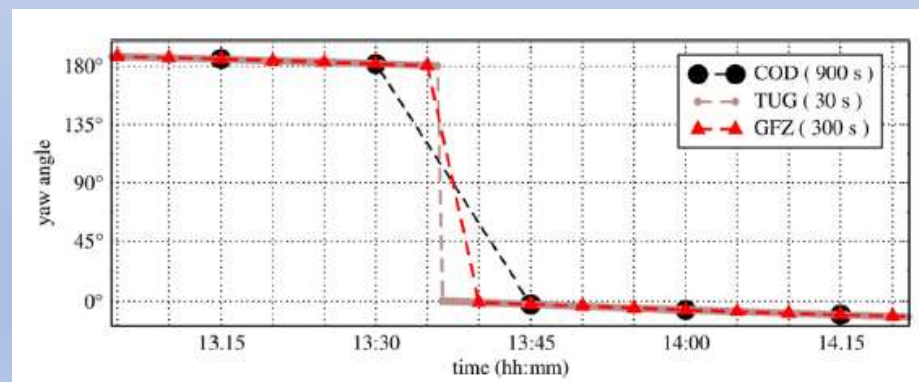
REPRO3 clock combination (Wuhan combi)
do use ATT.OBX files (presented last Tuesday by J. Geng)

- Naming convention is longnames for MGX : ok
- Different resolutions => Interpolation errors can be as huge as attitude differences
- 7 / 9 contributors for REPRO3
- Four Acs do contribute to att. files for MGEX on a regular basis

Current Availability of Att. on IGS Data/Products Centers

Names : *_30S_ATT.OBX.gz

AC	MGEX (01/06/2022)			Final Products (01/06/2022)
	COD	GRECJ	Finals	900s
GFZ	GRECJ	Rapids	300s	-
GRG	GRE	Finals	30s	GR (to be taken in MGEX files)
WUM	GRECJ	Ultra Rapids Finals	300 s 30 s	-



Progress on CNES/CLS Analysis Center side -Attitude for GRG/GRM products-

- **Orbex** files now proposed to users of our products
- New s/w version (**Gins**) to handle orbex files (replace internal attitude modelling)
 - Guarantee the compatibility with the clocks/biases : if attitude model change in the generation of the products (for any reason) the new attitudes models are « in » the orbex files : no s/w updates needed.
 - GNSS attitude files are also used to generate orbits of altimetry LEO satellites tracked with GNSS receivers on-board.
- Beidou (and associated attitude files) hopefully included in our MGEX products before end of 2022.

Attitude files : Possible Recommendations

Maintaining quality of clock products/combinations even in eclipse periods « imply » to deal with attitude quaternions :

- Encourage delivery of attitude files for MGEX products (today , only 3-4 ACs depending on the constellation)
- Temporal resolution should be at least equal to the clocks temporal resolution to avoid interpolation problems
- Others ?