Validation of Earth rotation time series by comparison of their sub-daily to sub-monthly excitation signal with simulated geophysical fluid model excitations.

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EGU 2020

EOP time series (x- / y-pole / UT1-UTC)

ESA-EOP project PR-EOP-TUM-17/01, contract # 4000120430/17/D/SR:
(see also D1695 | EGU2020-17154 Erik Schönemann et al.)

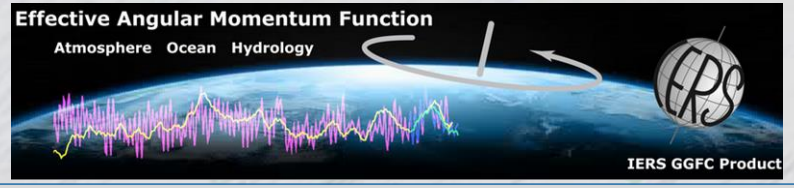
Experiment 1	combination of technique NEQs (VLBI, GNSS, SLR, DORIS) and solving for EOP with fixed station coordinates.
Experiment 2	like Experiment 1, but coordinates of stations contained in ITRF2014 have been transformed to ITRF2014 in advance.
Experiment 3	combination at observation level, GNSS / SLR only

IERS C04:	C04-08	until 2018-04-26
	C04-14	a posteriori combination of intra-technique EOPs, aligned to ITRF2014
JPL:	COMB2018	a posteriori combination of intra-technique EOPs, aligned to ITRF2014

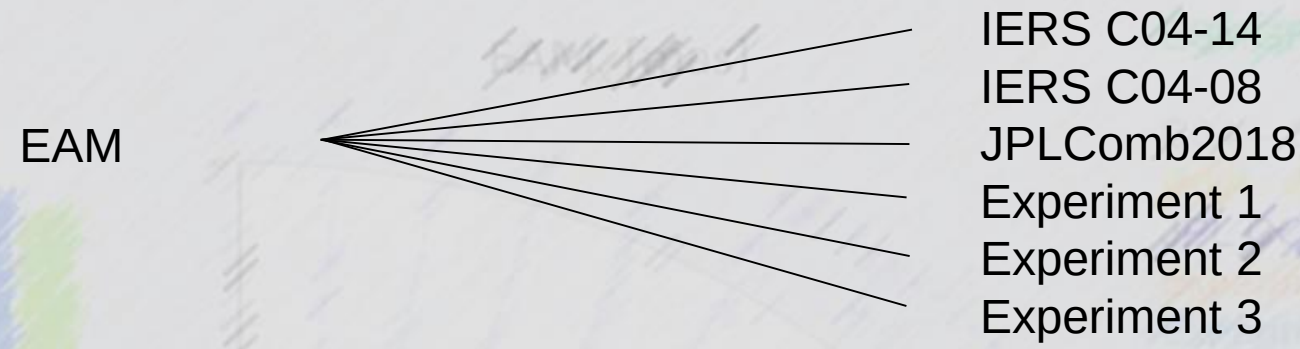
EAM time series (χ_1 / χ_2 / χ_3)

Effective angular momentum functions (as reference time series):

ESMGFZ http://esmdata.gfz-potsdam.de:8080/repository/



Analysis of EOP time series against modeled EAM



Reference series: ESMGFZ EAM = AAM + OAM + HAM + SLAM

Transform EOPs series into GAM series (Geodetic Angular Momentum)

Time series analysis and Amplitude spectra

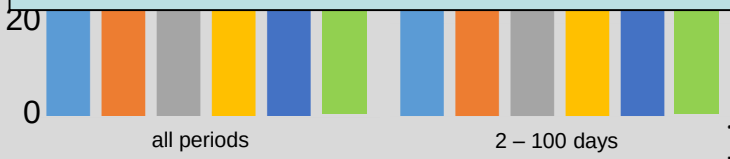
STD	Standard deviations of EOPs and ESMGFZ
RMSD	Difference between EOP series and ESMGFZ
CORR	Correlation between EOP series and ESMGFZ
Expl.Var	Explained Variance of ESMGFZ by EOP series

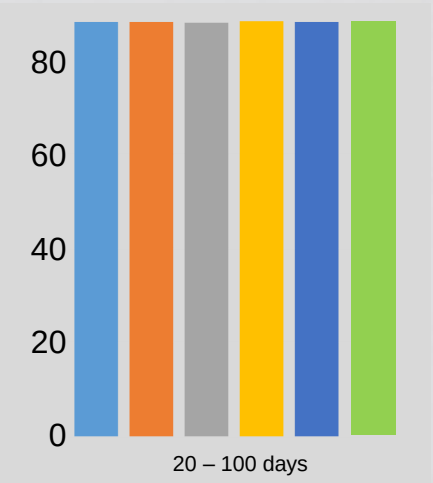
Period bands all periods 2 – 100 days 20 - 100 days 8 – 20 days 2 – 8 days

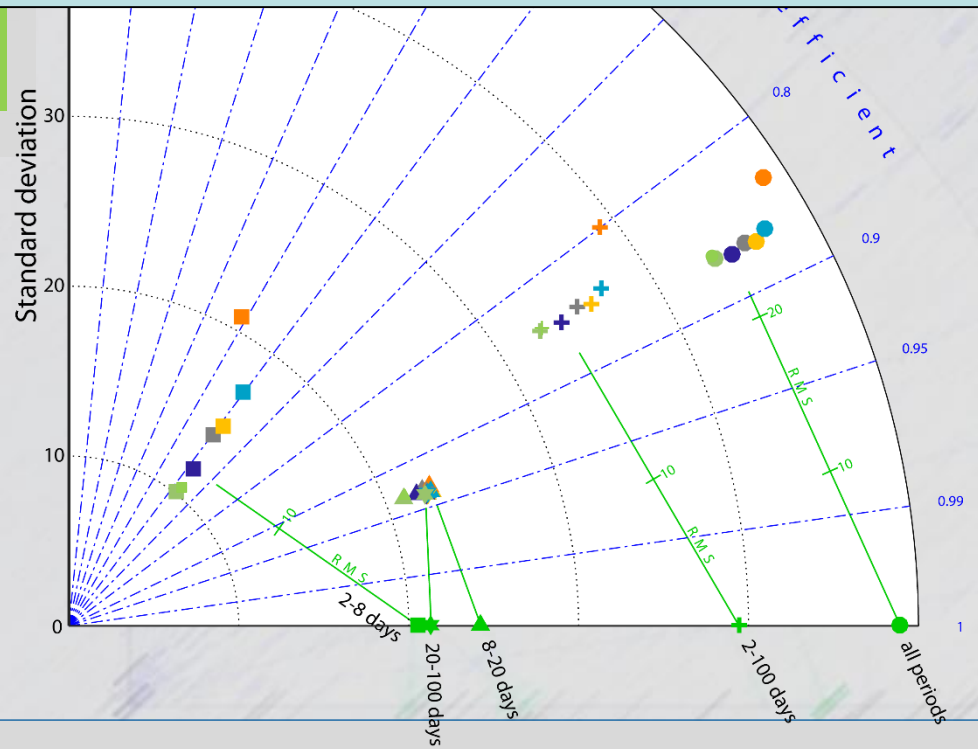
STD – CORR – RMSD – Expl. Variance

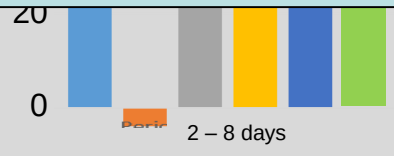
$$RMSD(i)^2 = STD(i)^2 + STD_{ref}^2 - 2 * STD(i) * STD_{ref} * CORR(i)$$

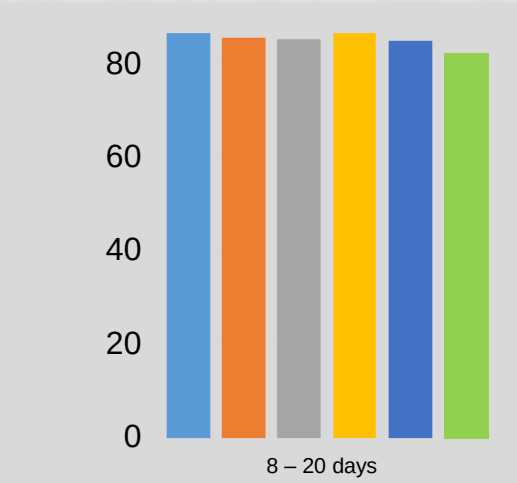
This Taylor diagrams do not only display results for the different GAM series (each by a separate color), but also for the different filters applied (each by a separate marker). For each category, the STD_{ref} of the geophysical model-based time series ESMGFZ is given at the axis of abscissa as the reference point. The Euclidean distance from the reference point to the marker (STD(i),CORR(i)) of an individual series gives the RMSD(i).







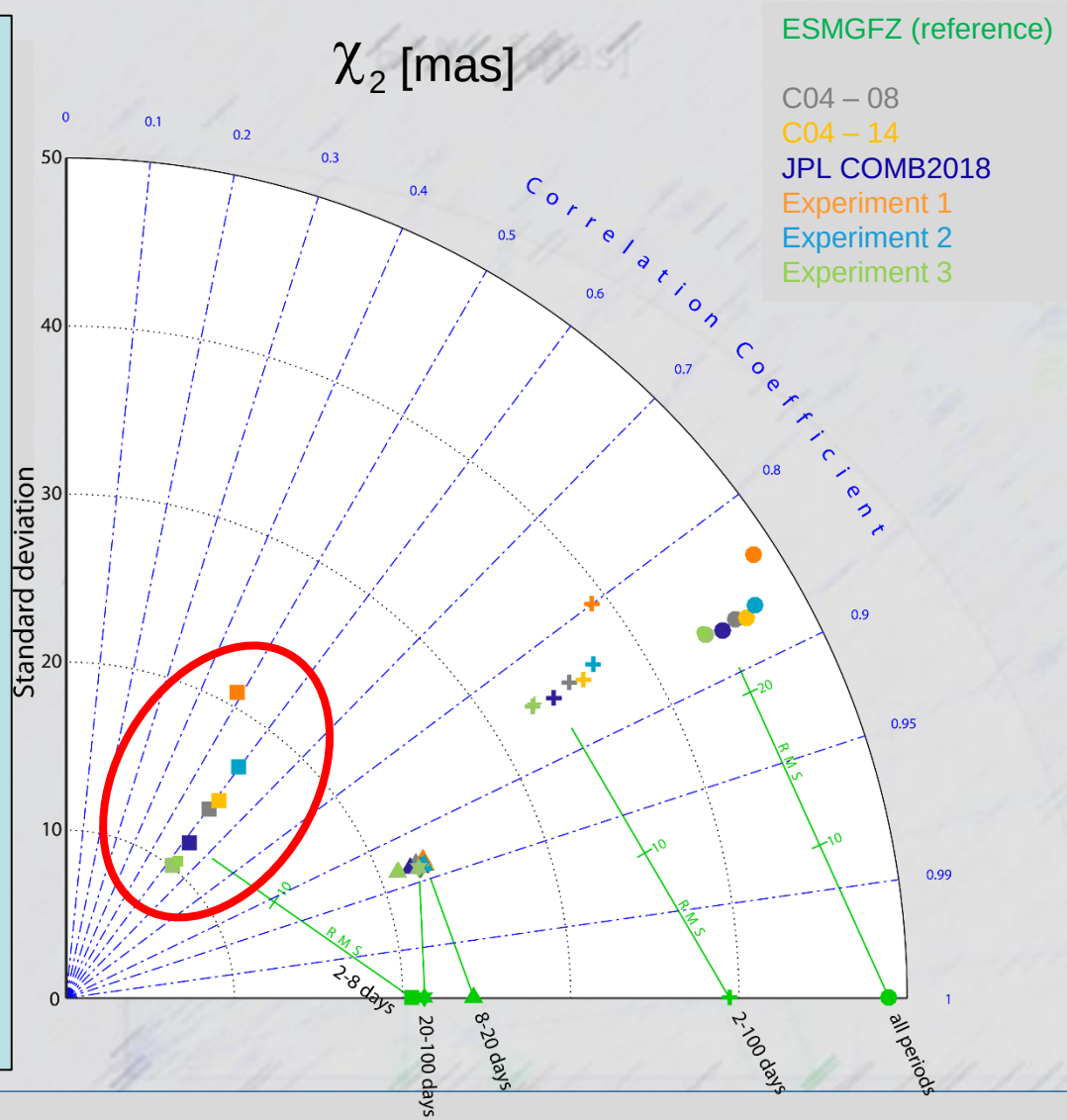




STD – CORR – RMSD – Expl. Variance

Equatorial components:

- Generally good correspondence of all GAM series with modelled EAM.
- Results for 8 – 20 (triangles) and 20 -- 100 days (stars) are very close to each other.
- Substantially larger spread for periods below 8 days (squares): C04-08 and C04-14 very close, with slightly smaller RMSD and higher CORR for more recent series. JPL Comb18 notable smaller STD than C04,
- Huge reduction in STD for Experiment 2 compared to Experiment 1 although both experiments only differ in the treatment of the station coordinates (as given in the SINEX files for E1; taken from ITRF2014 where possible for E2).

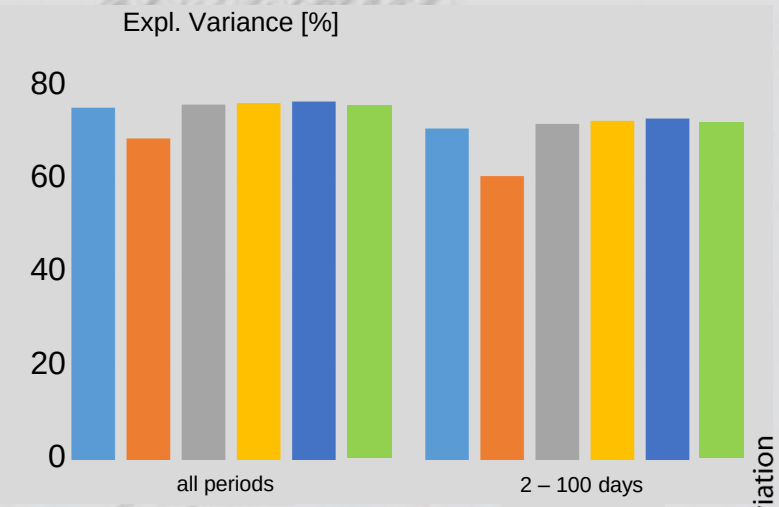


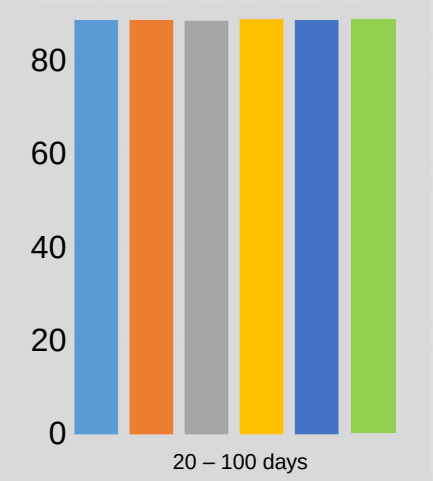
Note 1:
Precise a priori coordinates very important for determination of EOP.

Keeping a priori station coordinates as given in the intra-technique NEQs (Exp. 1) leads to spurious high frequency signals that almost entirely mask the real geophysical signal contained in the geodetic observations.
Differences in the station coordinates were eliminated in NEQS of Exp. 2.

Note 2:
Experiment 3 (combination at observation level) has always the smallest STD from all geodetic time-series considered. Although so far no VLBI and DORIS information included in E3, CORR and RMSD are already quite competitive. Pole coordinates are very well determined from GNSS and SLR information alone.

STD – CORR – RMSD – Expl. Variance

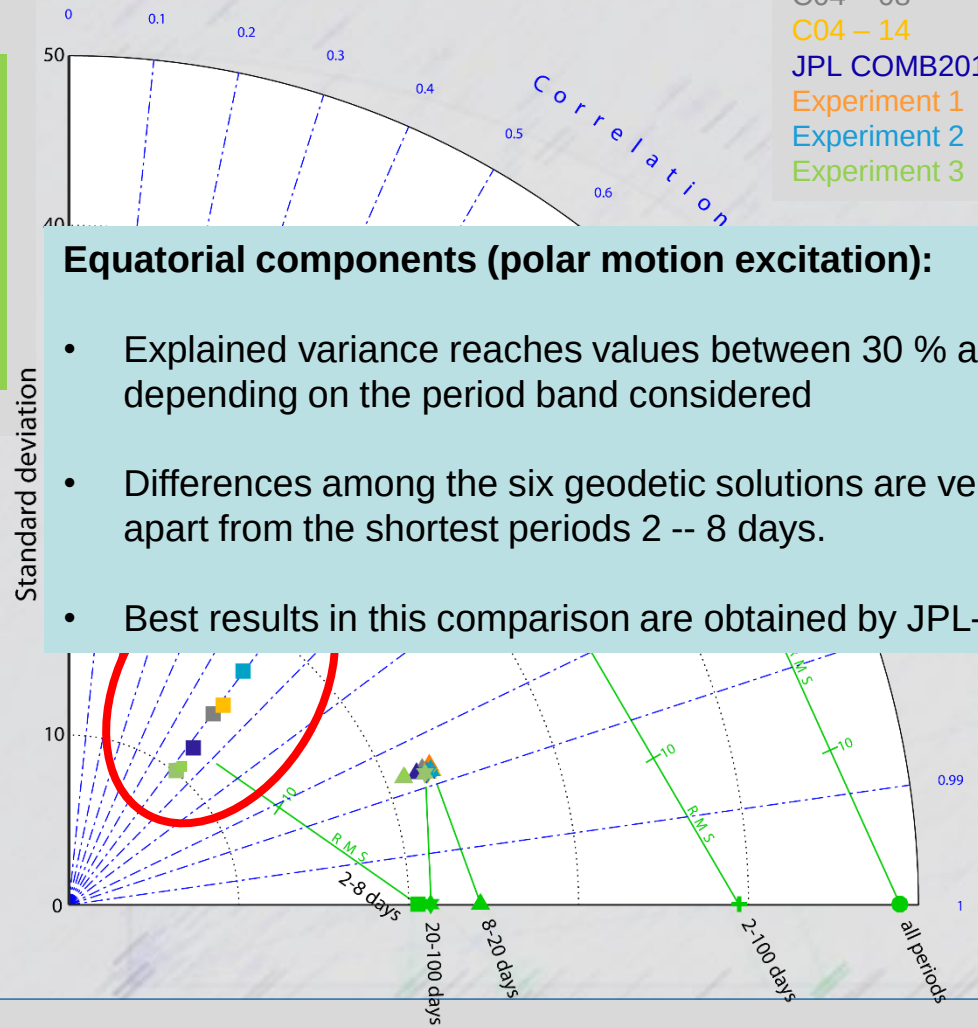




χ_2 [mas]

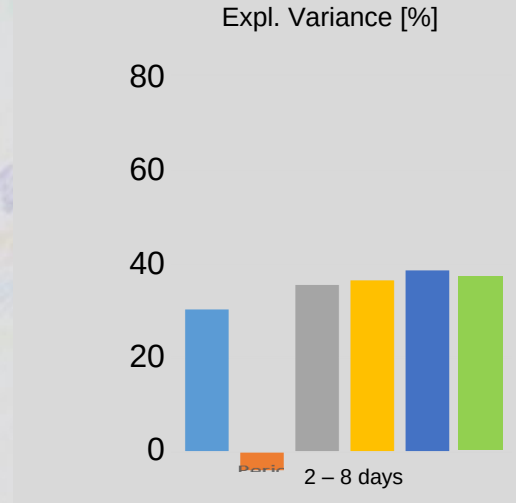
ESMGFZ (reference)

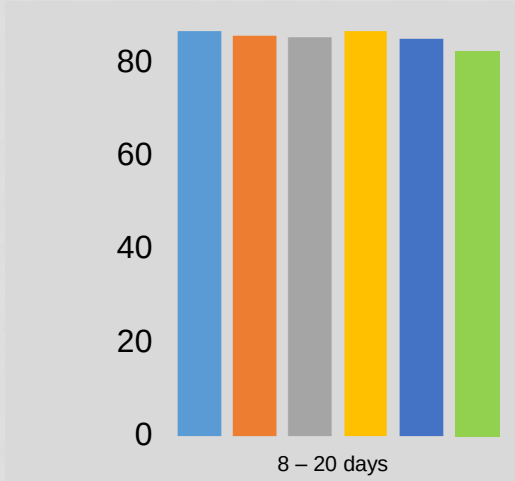
C04 – 08
C04 – 14
JPL COMB2018
Experiment 1
Experiment 2
Experiment 3



Equatorial components (polar motion excitation):

- Explained variance reaches values between 30 % and 75 % depending on the period band considered
- Differences among the six geodetic solutions are very small apart from the shortest periods 2 -- 8 days.
- Best results in this comparison are obtained by JPL-Comb2018.

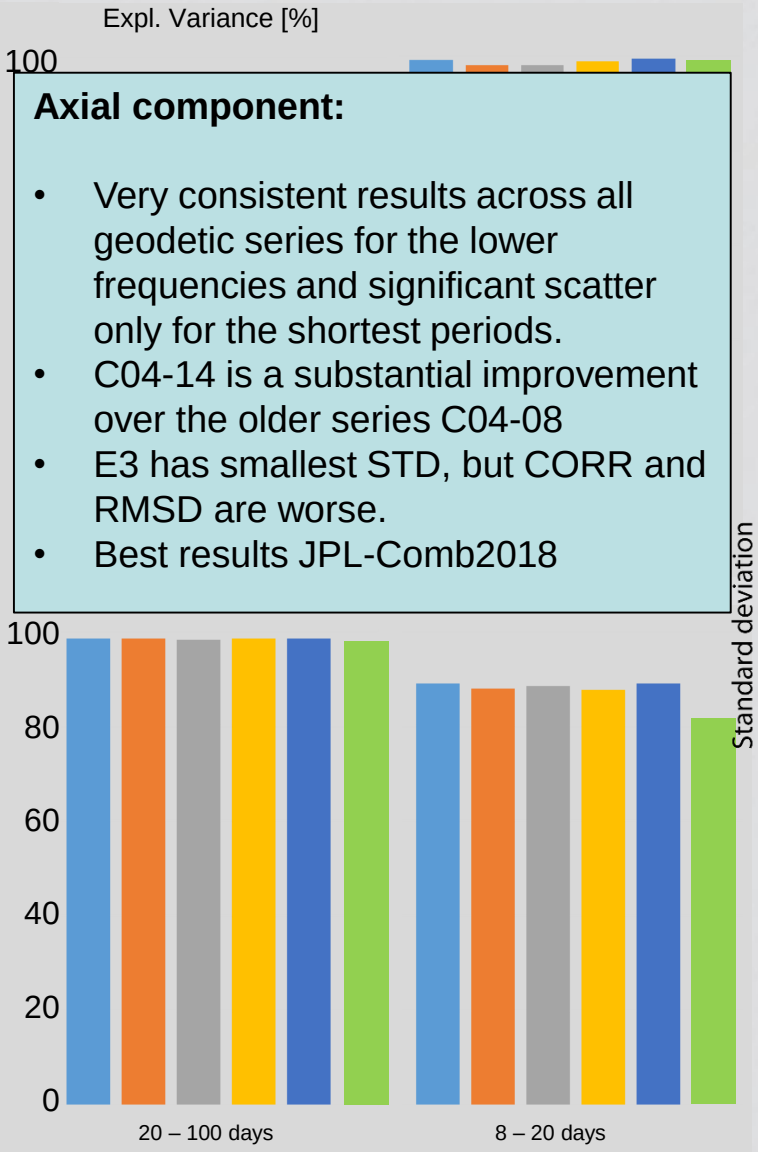


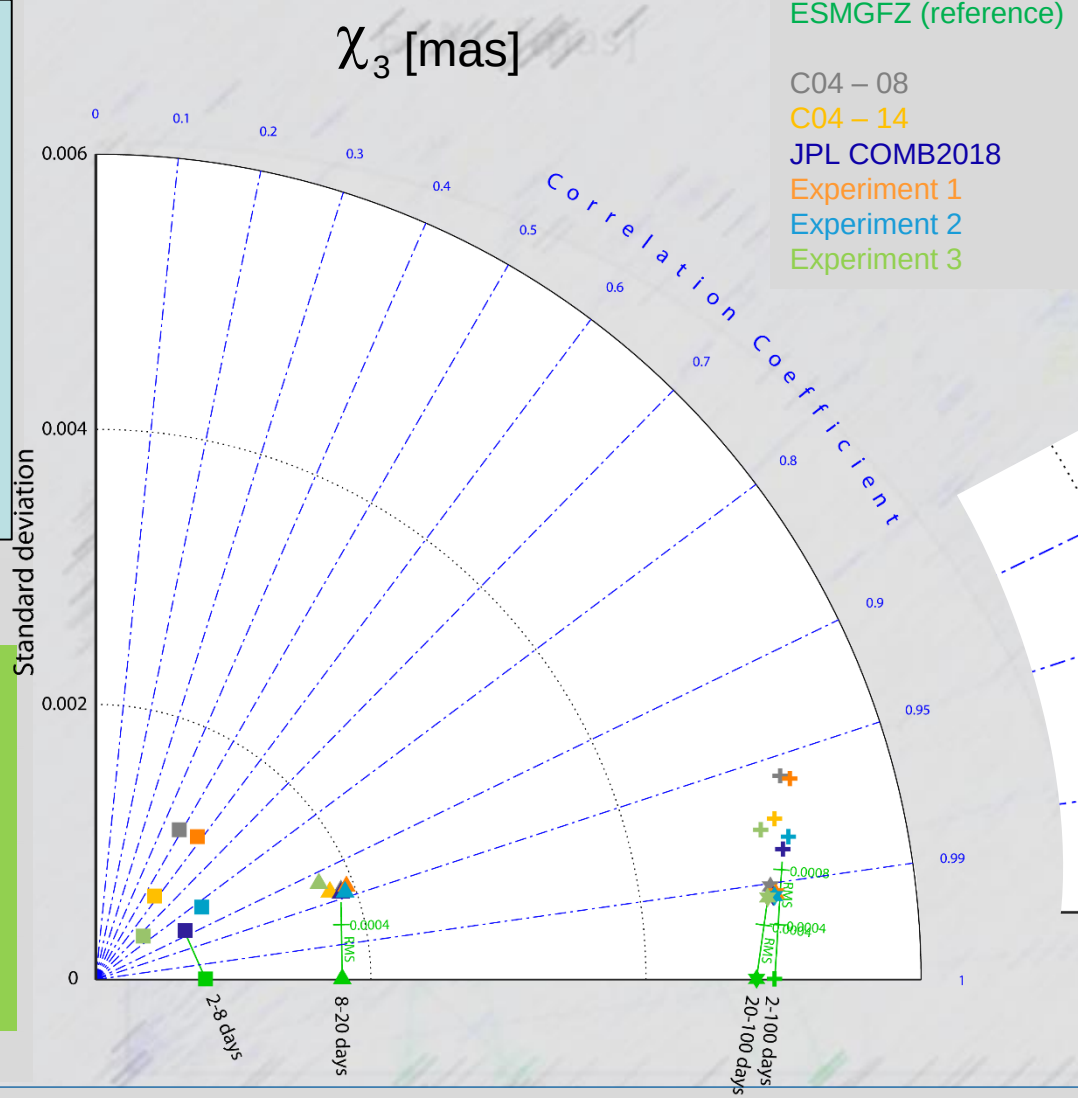


STD – CORR – RMSD – Expl. Variance

Axial component:

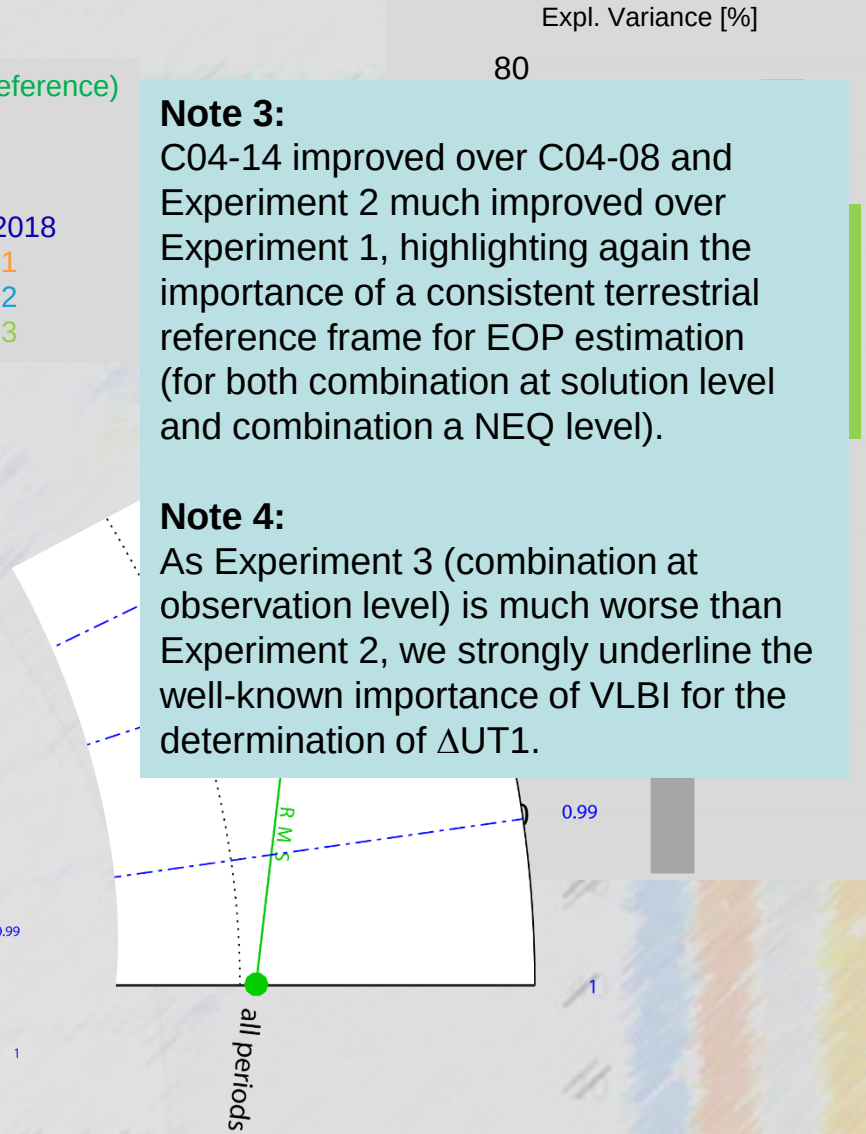
- Very consistent results across all geodetic series for the lower frequencies and significant scatter only for the shortest periods.
- C04-14 is a substantial improvement over the older series C04-08
- E3 has smallest STD, but CORR and RMSD are worse.
- Best results JPL-Comb2018





ESMGFZ (reference)

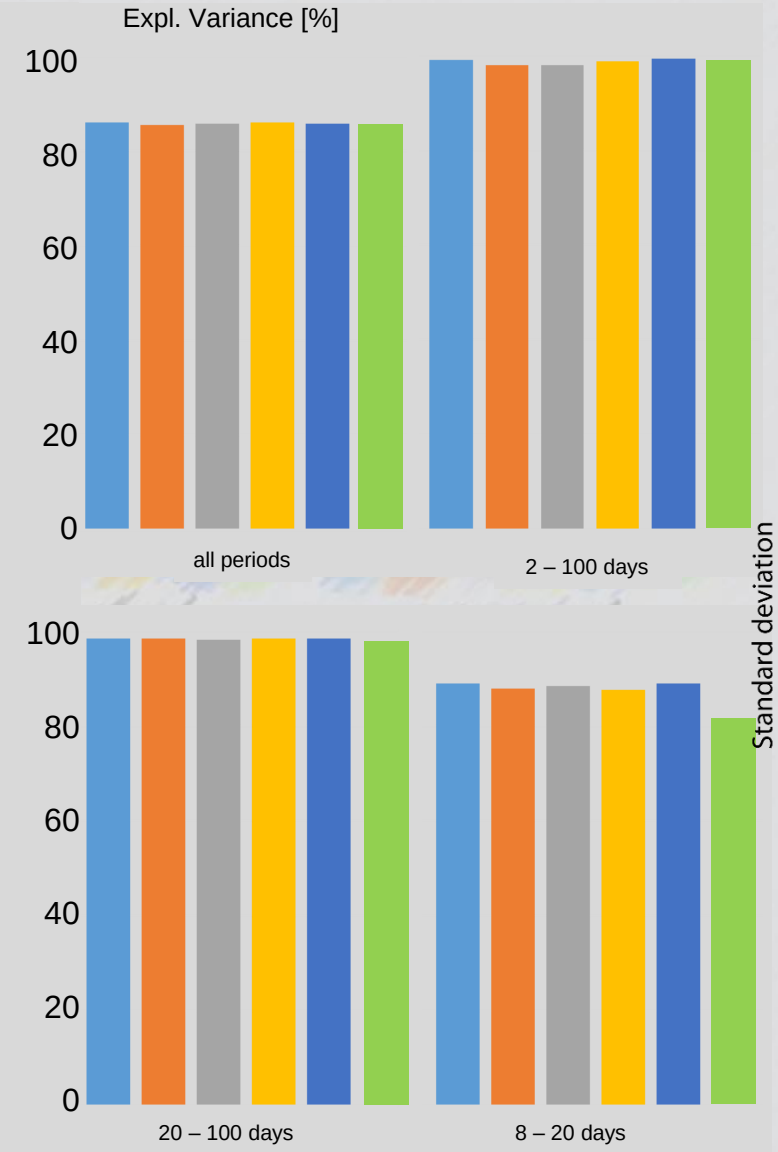
C04 – 08
C04 – 14
JPL COMB2018
Experiment 1
Experiment 2
Experiment 3



Note 3:
C04-14 improved over C04-08 and Experiment 2 much improved over Experiment 1, highlighting again the importance of a consistent terrestrial reference frame for EOP estimation (for both combination at solution level and combination a NEQ level).

Note 4:
As Experiment 3 (combination at observation level) is much worse than Experiment 2, we strongly underline the well-known importance of VLBI for the determination of ΔUT1.

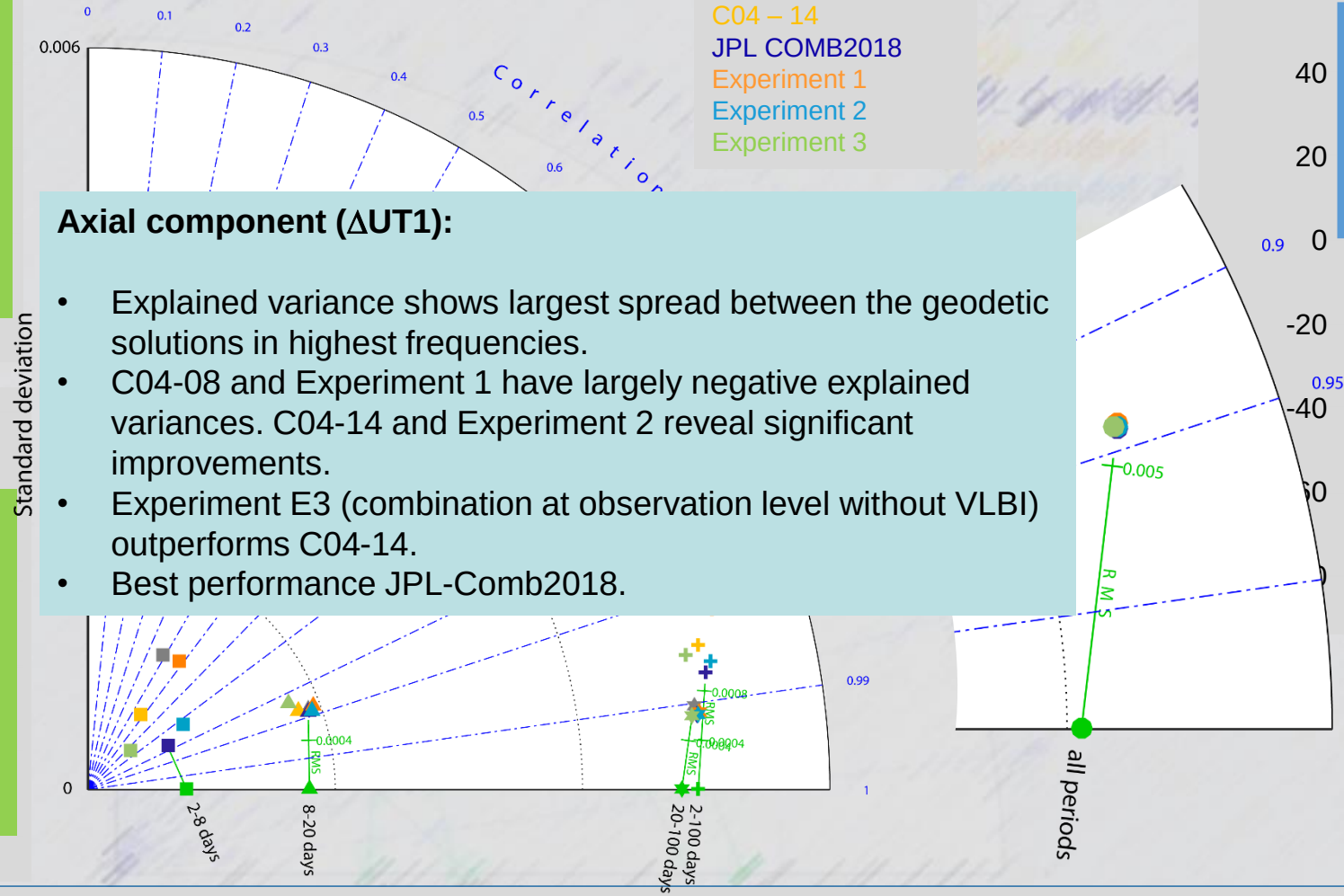
STD – CORR – RMSD – Expl. Variance



χ_3 [mas]

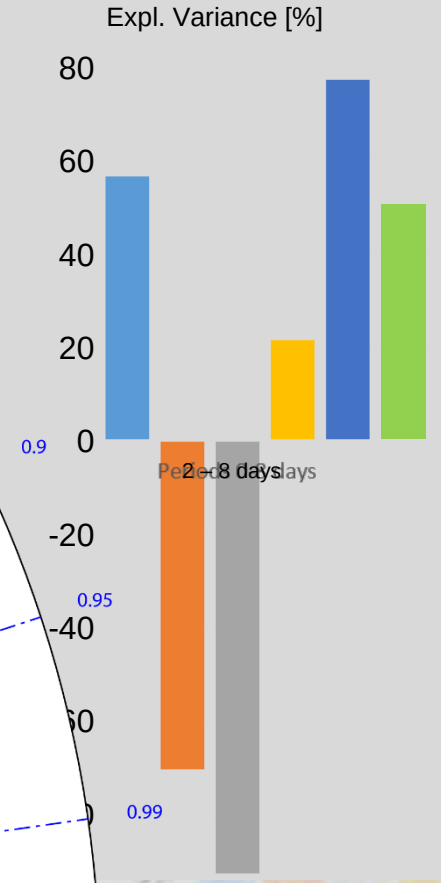
ESMGFZ (reference)

C04 – 08
C04 – 14
JPL COMB2018
Experiment 1
Experiment 2
Experiment 3

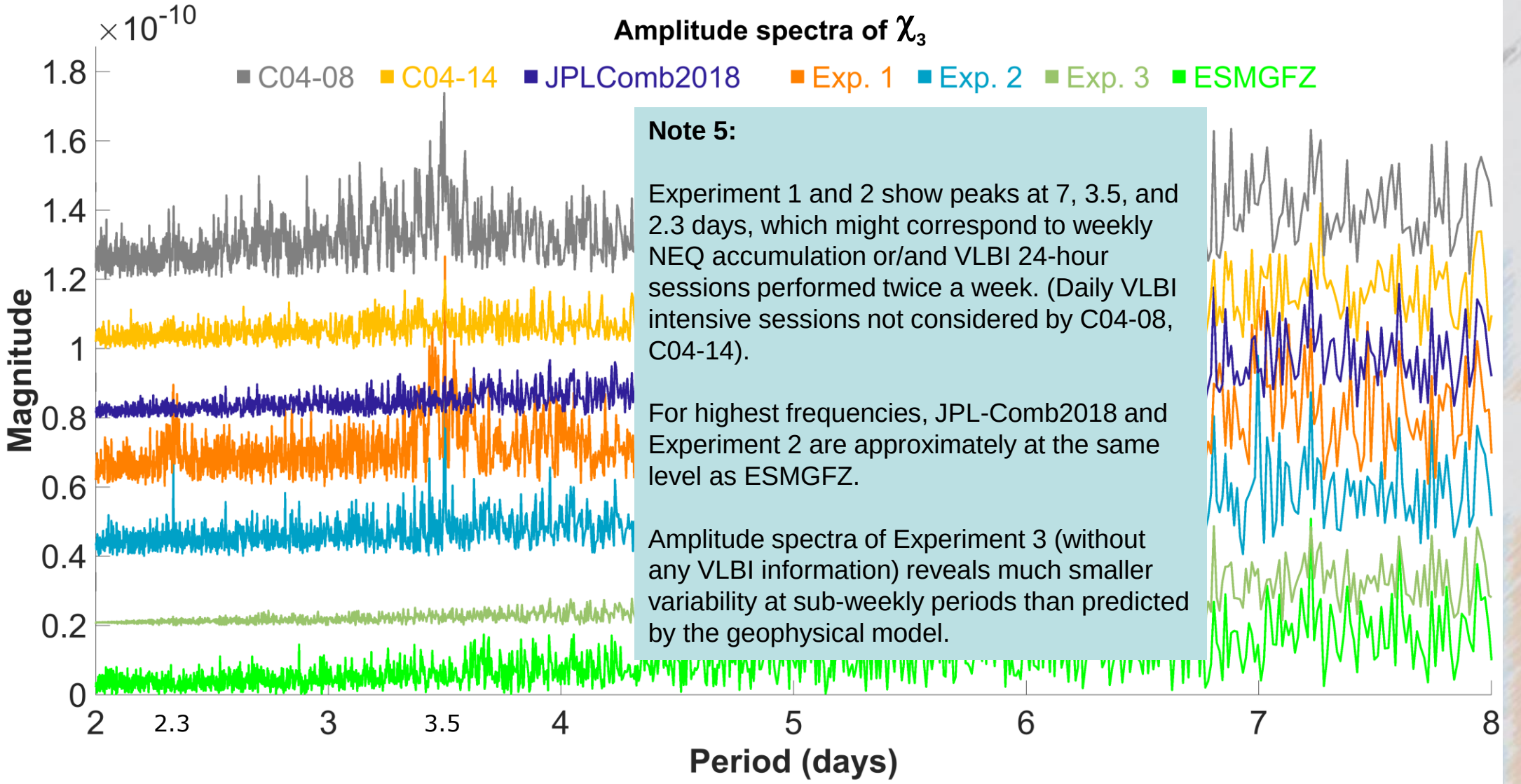


Axial component (ΔUT1):

- Explained variance shows largest spread between the geodetic solutions in highest frequencies.
- C04-08 and Experiment 1 have largely negative explained variances. C04-14 and Experiment 2 reveal significant improvements.
- Experiment E3 (combination at observation level without VLBI) outperforms C04-14.
- Best performance JPL-Comb2018.



High-frequency variations (2 – 8 days)



Note 5:

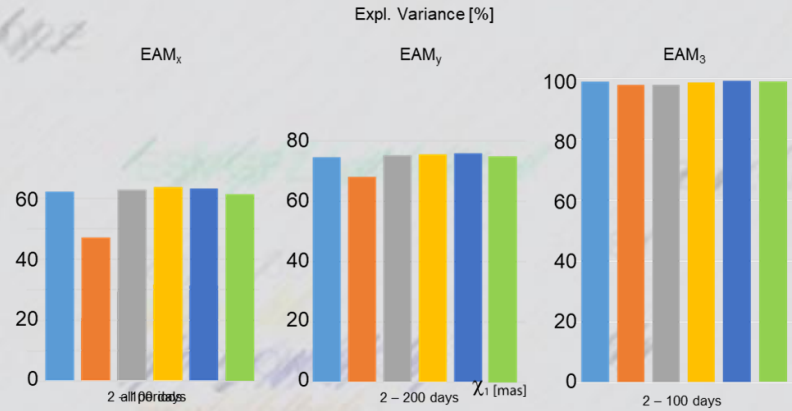
Experiment 1 and 2 show peaks at 7, 3.5, and 2.3 days, which might correspond to weekly NEQ accumulation or/and VLBI 24-hour sessions performed twice a week. (Daily VLBI intensive sessions not considered by C04-08, C04-14).

For highest frequencies, JPL-Comb2018 and Experiment 2 are approximately at the same level as ESMGFZ.

Amplitude spectra of Experiment 3 (without any VLBI information) reveals much smaller variability at sub-weekly periods than predicted by the geophysical model.

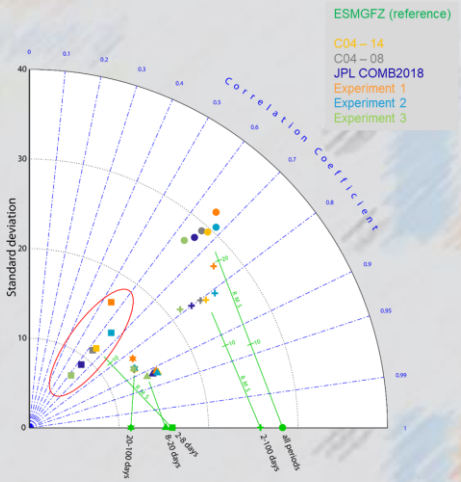
Results

- **Comparison at EAM level with ESMGFZ as independent reference is feasible**



- **Combined ERPs are very sensible to inconsistencies in the realization of the reference system of each technique**

(Differences occur in the highest frequencies of EAM)



- **JPL Comb2018, Exp. 2, Exp. 3 better than C04**

(Exp. 3 still preliminary, no VLBI)