SLR DATA PROCESSING OF SPHERICAL SATELLITES AT AIUB

Linda Geisser, Ulrich Meyer, Daniel Arnold, Adrian Jäggi

from

Astronomical Institute, University of Bern, Switzerland

COSPAR-2021-Hybrid, 29 January 2021

OUTLINE

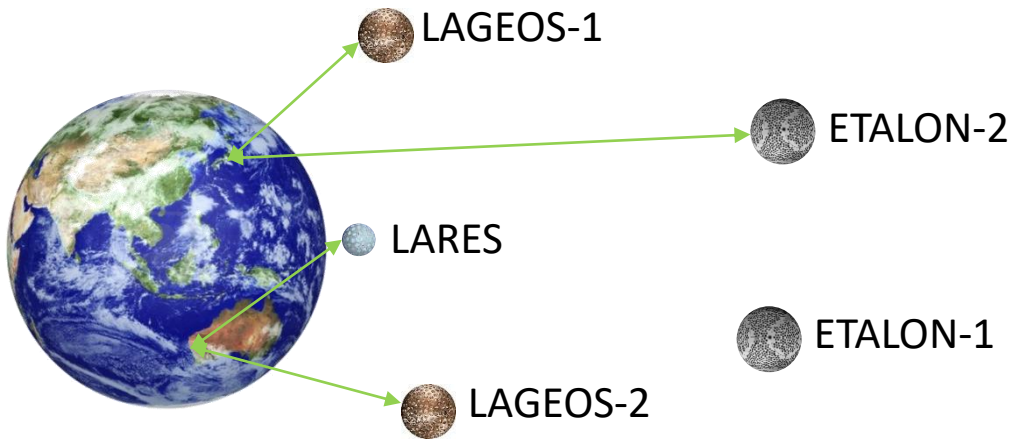
- Introduction
  - What is SLR
  - Parametrization
- Analysis
  - Compare estimated geodetic parameters of different SLR solutions
- Summary and Outlook

WHAT IS SATELLITE LASER RANGING

Outline:

- Introduction
- Analysis
- Summary and Outlook

- Runtime measurement of a laser beam (e.g. λ: 532/1064 nm) from a station to a satellite with retroreflectors
- To determine geodetic parameters, e.g. Earth rotation parameters (ERPs), station coordinates, geocenter



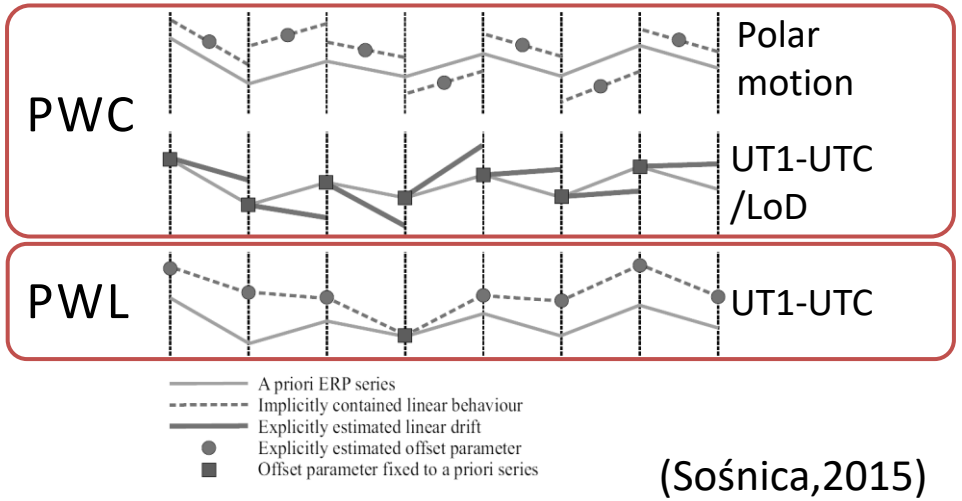
Zimmerwald in Switzerland

PARAMETRIZATION

Outline:

- Introduction
- Analysis
- Summary and Outlook

Parametrization \ Satellites	LAGEOS-1/2 ETALON-1/2	LARES
Osculating elements	$a, e, i, \Omega, \omega, u_0$	
	1 set per 7 days	
Constant and once-per-rev accelerations	S_0, S_S, S_C, W_S, W_C	
	1 set per 7 days	1 set per 7 days
		1 set per day
Pseudo-stochastic pulses	No pulses	In along-track (twice per day)
Earth rotation parameters	$X_P, Y_P, UT1 - UTC$	
	Piecewise-constant	
	Piecewise-linear	
Geocenter coordinates	1 set per 7 days	
	Fixed Geocenter	
Station coordinates	1 set per 7 days	
	Loosely constrained	
	NNR and NNT solution	
Range biases	1 set per 7 days for	
	selected stations	all stations



(Sośnica,2015)

PWC | PWL

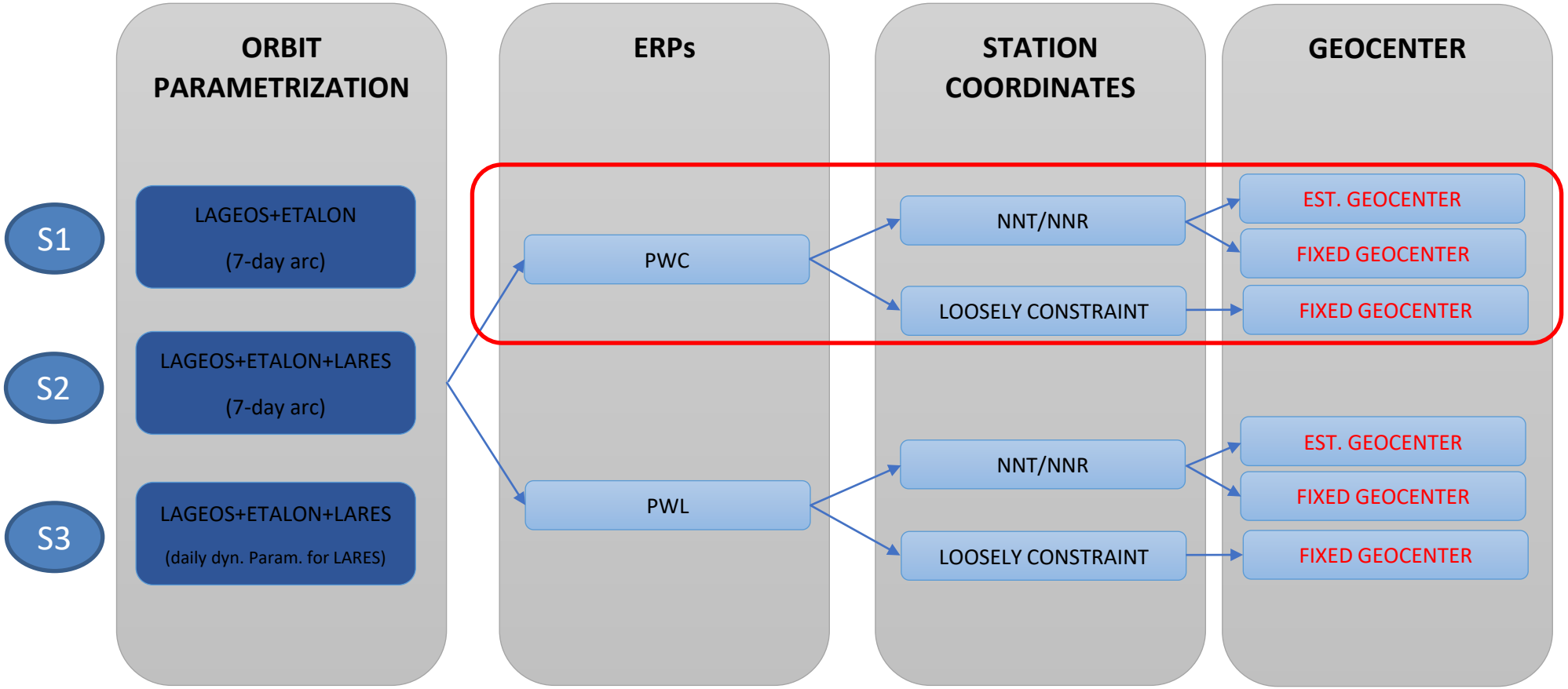
EST. GEOCENTER | FIXED GEOCENTER

LOOSELY CONSTRAINT | NNT/NNR

DIFFERENT SLR-SOLUTIONS

Outline:

- Introduction
- Analysis
- Summary and Outlook



COMPARISON OF EARTH ROTATION PARAMETERS

Outline:

- Introduction
- Analysis (PWC)
  - ERPs
  - Station coord.
  - Geocenter
- Summary and Outlook

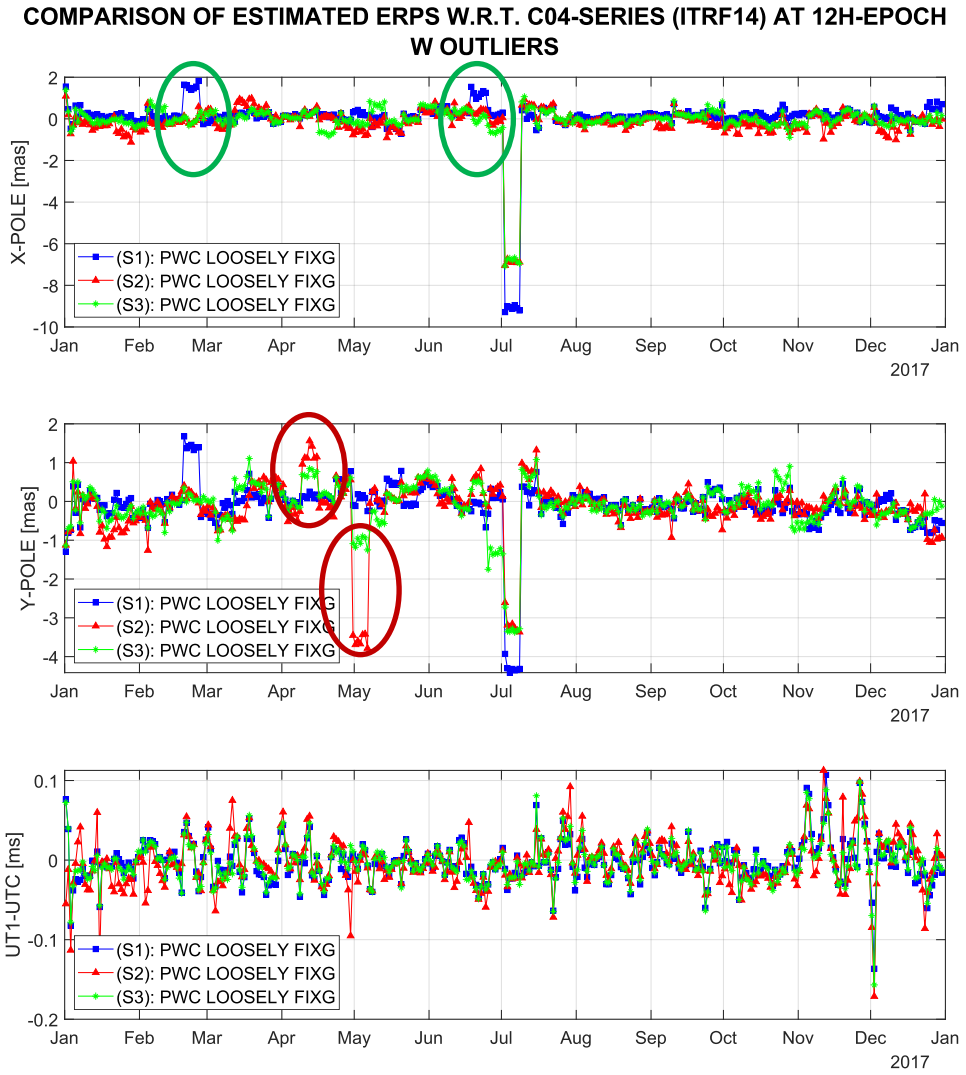
PWC → LOOSELY CONSTRAINT

Abbreviations:

(S1): LAGEOS+ETALON (7-day arcs)

(S2): LAGEOS+ETALON+ LARES (7-day arcs)

(S3): LAGEOS+ETALON+ LARES (daily dyn. Param. for LARES)

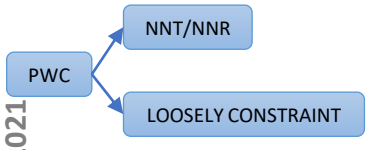


- Several outliers
  - LARES can stabilize
  - caused by LARES
- Sensitive to the a priori orbits through the screening

COMPARISON OF EARTH ROTATION PARAMETERS

Outline:

- Introduction
- Analysis (PWC)
  - ERPs
  - Station coord.
  - Geocenter
- Summary and Outlook

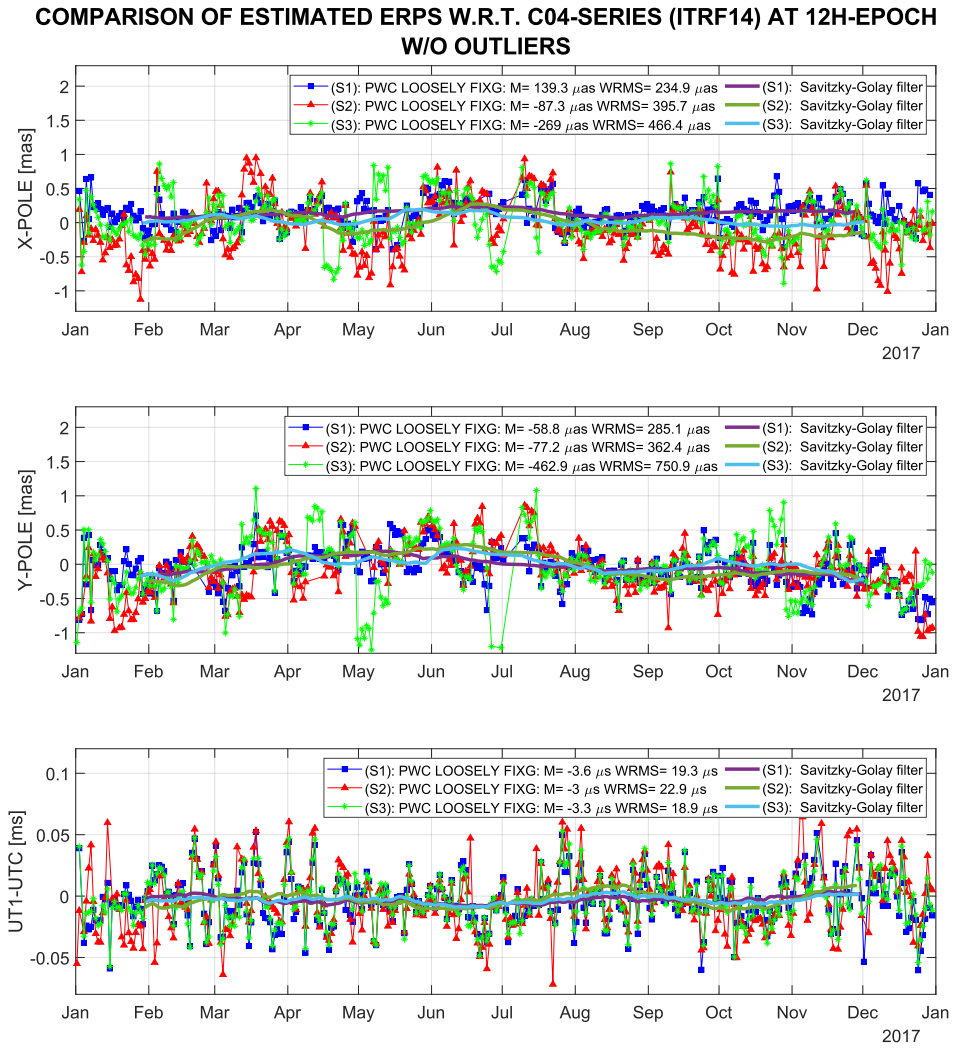


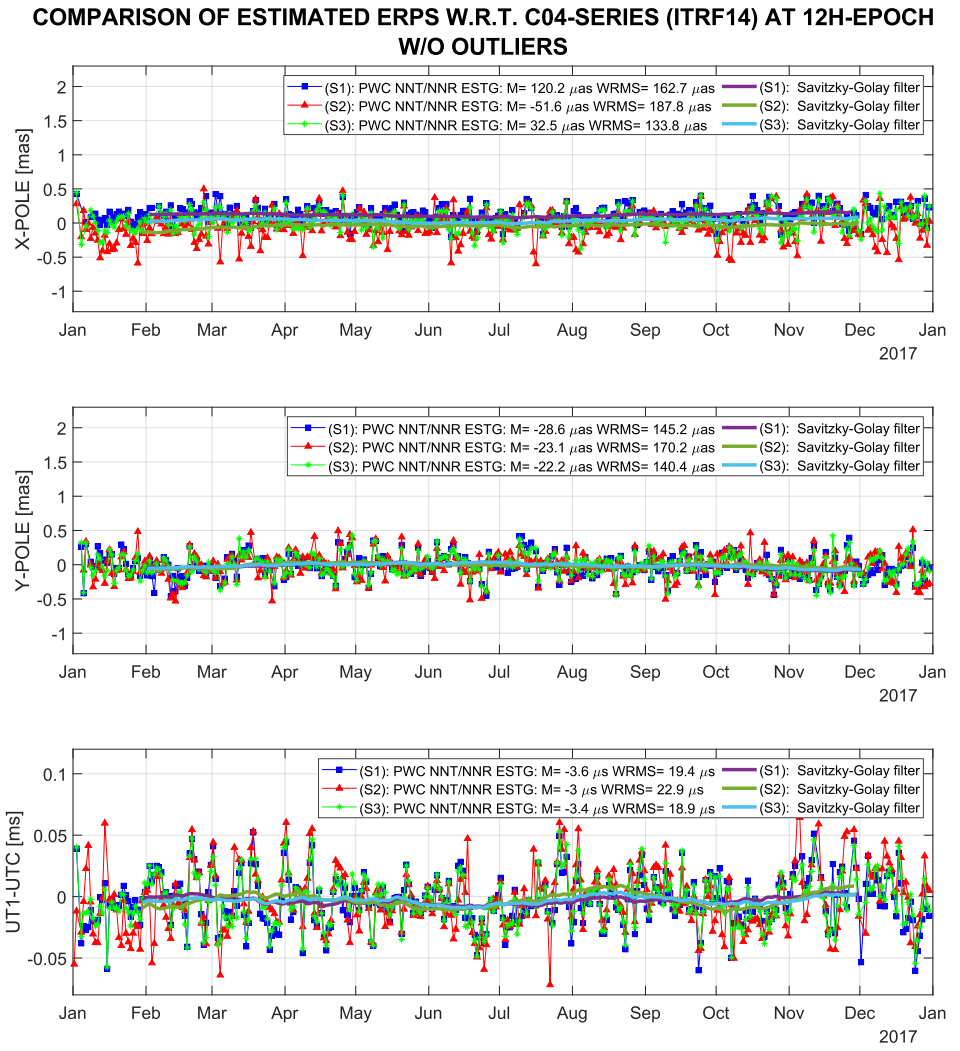
Abbreviations:

(S1): LAGEOS+ETALON (7-day arcs)

(S2): LAGEOS+ETALON+ LARES (7-day arcs)

(S3): LAGEOS+ETALON+ LARES (daily dyn. Param. for LARES)

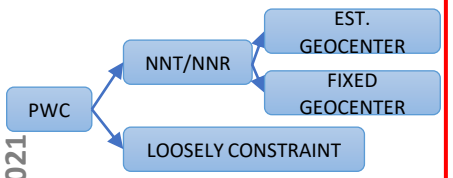




COMPARISON OF EARTH ROTATION PARAMETERS

Outline:

- Introduction
- Analysis (PWC)
  - ERPs
  - Station coord.
  - Geocenter
- Summary and Outlook



Abbreviations:

(S1): LAGEOS+ETALON (7-day arcs)

(S2): LAGEOS+ETALON+ LARES (7-day arcs)

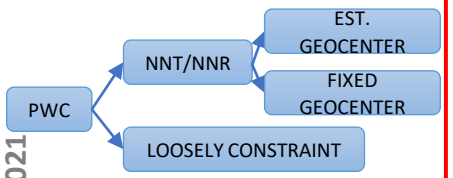
(S3): LAGEOS+ETALON+ LARES (daily dyn. Param. for LARES)

Solutions			X pole [μas]		Y pole [μas]		UT1-UTC [μs]	
Used satellites	Station coordinates	Geocenter	Bias	WRMS	Bias	WRMS	Bias	WRMS
(S1): LAGEOS+ETALON	Loosely	fixed	139.3	234.9	-58.8	285.1	-3.6	19.3
	NNT/NNR	estimated	120.2	162.7	-28.6	145.2	-3.6	19.4
		fixed	144.8	181.8	-34.4	149.8	-3.2	18.9
(S2): LAGEOS+ETALON+ LARES (7-day arcs)	Loosely	fixed	-87.3	395.7	-77.2	362.4	-3.0	22.9
	NNT/NNR	estimated	-51.6	187.8	-23.1	170.2	-3.0	22.9
		fixed	-16.2	179.9	-3.4	165.1	-2.1	22.5
(S3) : LAGEOS+ETALON+ LARES (daily dyn. Parameters for LARES)	Loosely	fixed	-269	466.4	-462.9	750.9	-3.3	18.9
	NNT/NNR	estimated	32.5	133.8	-22.2	140.4	-3.4	18.9
		fixed	61.3	151.3	-13.7	146.8	-2.7	18.6

COMPARISON OF EARTH ROTATION PARAMETERS

Outline:

- Introduction
- Analysis (PWC)
  - ERPs
  - Station coord.
  - Geocenter
- Summary and Outlook



Abbreviations:

(S1): LAGEOS+ETALON (7-day arcs)

(S2): LAGEOS+ETALON+ LARES (7-day arcs)

(S3): LAGEOS+ETALON+ LARES (daily dyn. Param. for LARES)

Solutions			X pole $[\mu as]$		Y pole $[\mu as]$		UT1-UTC $[\mu s]$	
Used satellites	Station coordinates	Geocenter	Bias	WRMS	Bias	WRMS	Bias	WRMS

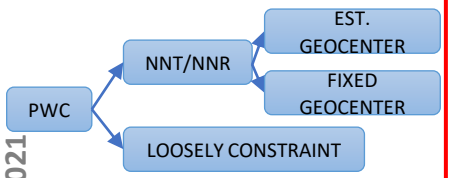
Conclusion:

- Use a good datum definition
- LARES parametrization has to be extended as for example in (S3)
- If a good parametrization is used, the estimation of geocenter coordinates can slightly improve the ERPs

COMPARISON OF HELMERT TRANSFORMATION

Outline:

- Introduction
- Analysis (PWC)
  - ERPs
  - Station coord.
  - Geocenter
- Summary and Outlook

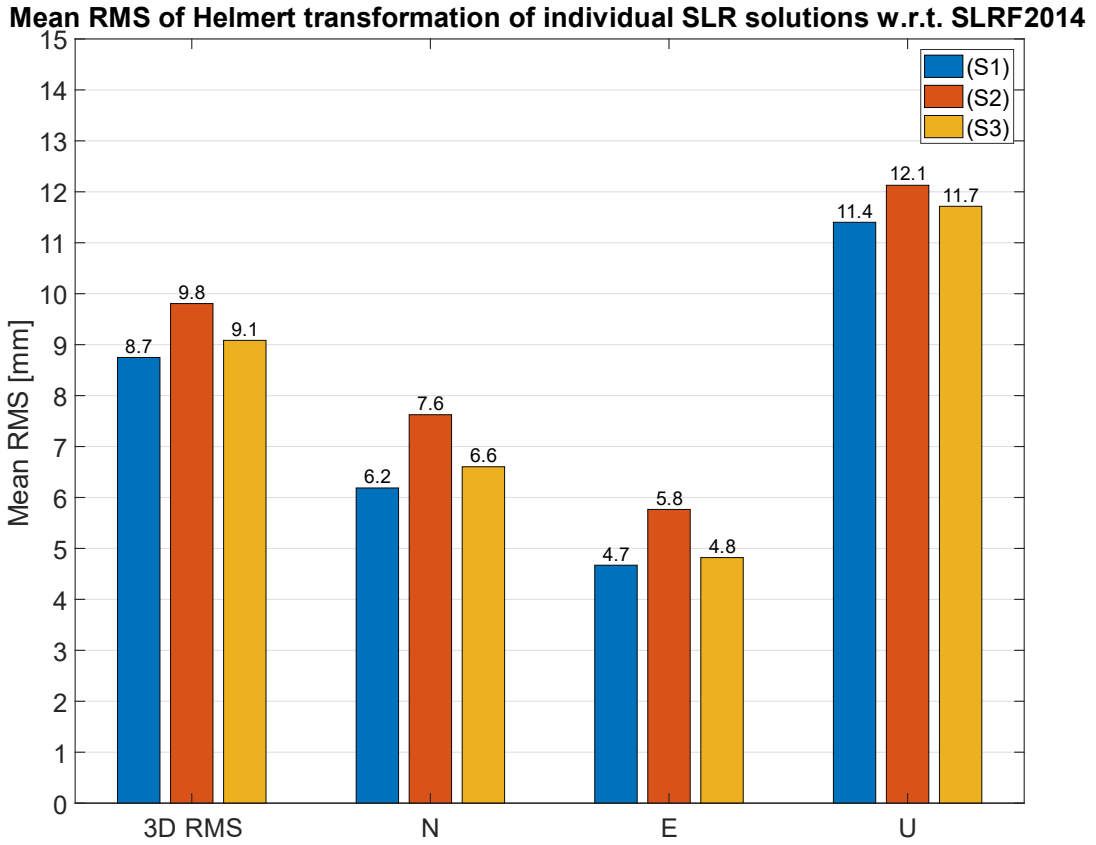


Abbreviations:

(S1): LAGEOS+ETALON (7-day arcs)

(S2): LAGEOS+ETALON+ LARES (7-day arcs)

(S3): LAGEOS+ETALON+ LARES (daily dyn. Param. for LARES)

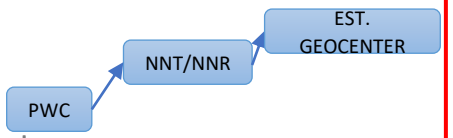


- If a good LARES orbit parametrization is used, the RMS of Helmert transformations can be decreased

COMPARISON OF THE GEOCENTER

Outline:

- Introduction
- Analysis (PWC)
  - ERPs
  - Station coord.
  - Geocenter
- Summary and Outlook

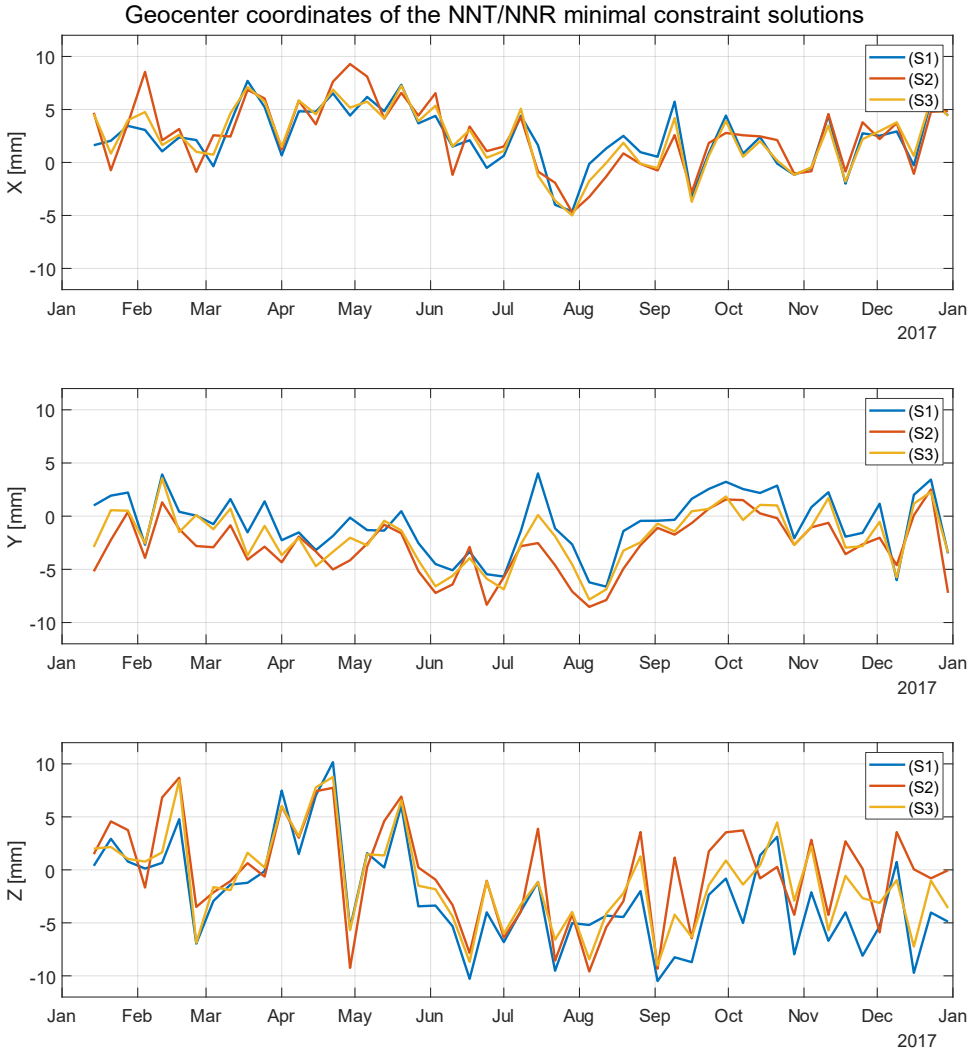


Abbreviations:

(S1): LAGEOS+ETALON (7-day arcs)

(S2): LAGEOS+ETALON+ LARES (7-day arcs)

(S3): LAGEOS+ETALON+ LARES (daily dyn. Param. for LARES)

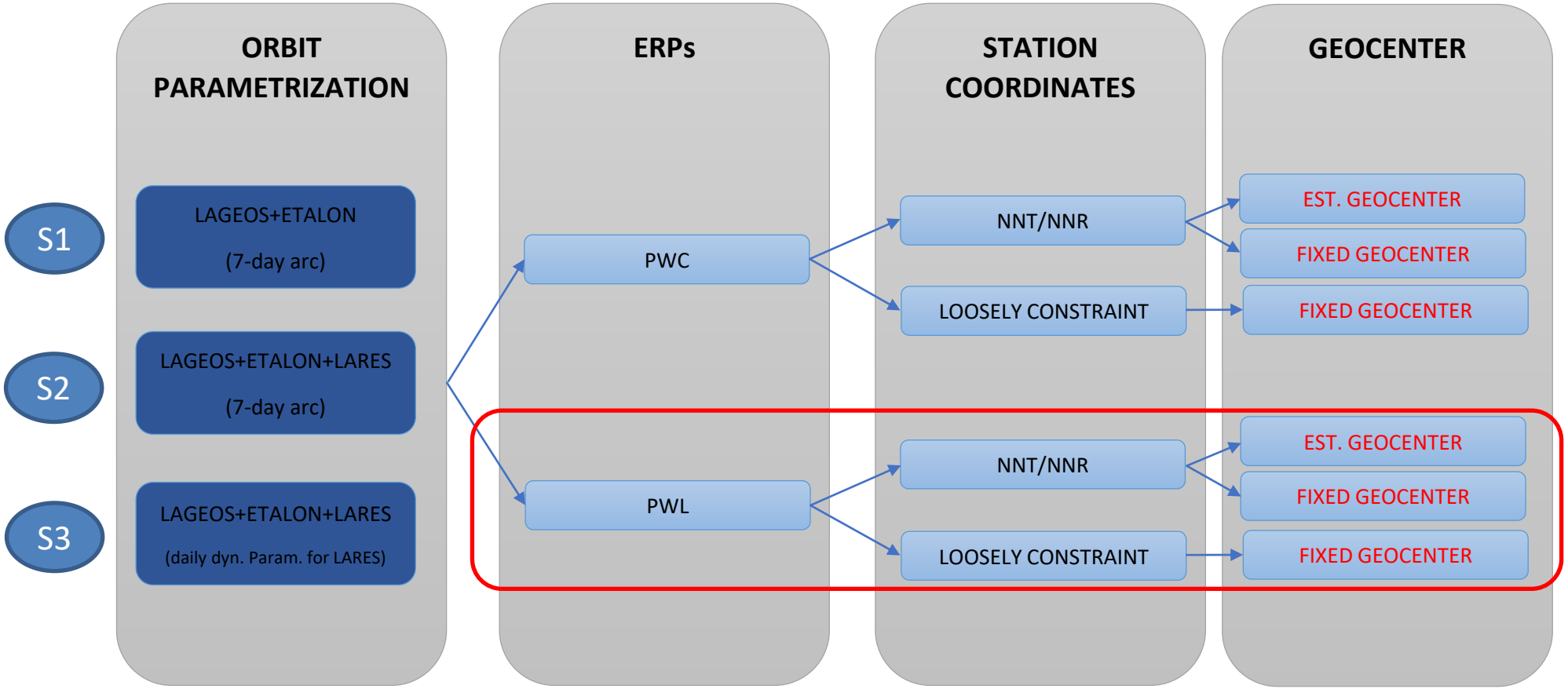


- The time series of the geocenter from solution (S3) fits better to (S1) than (S2)

DIFFERENT SLR-SOLUTIONS

Outline:

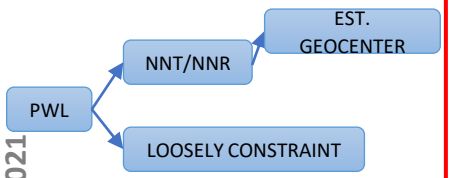
- Introduction
- Analysis
- Summary and Outlook



COMPARISON OF EARTH ROTATION PARAMETERS

Outline:

- Introduction
- Analysis (PWL)
  - ERPs
- Summary and Outlook

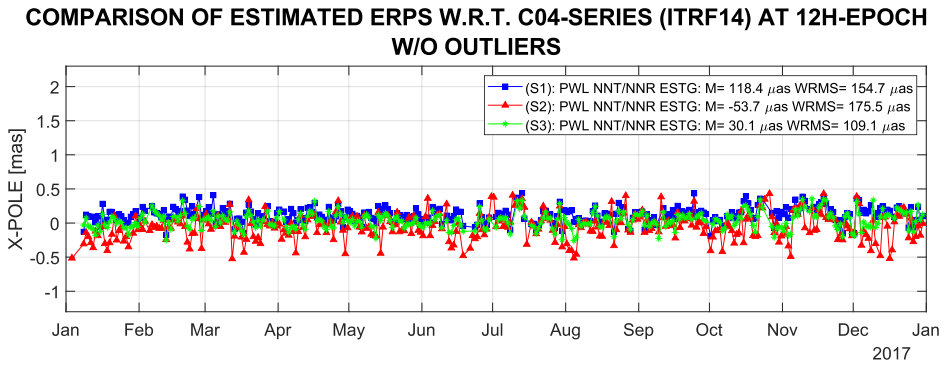


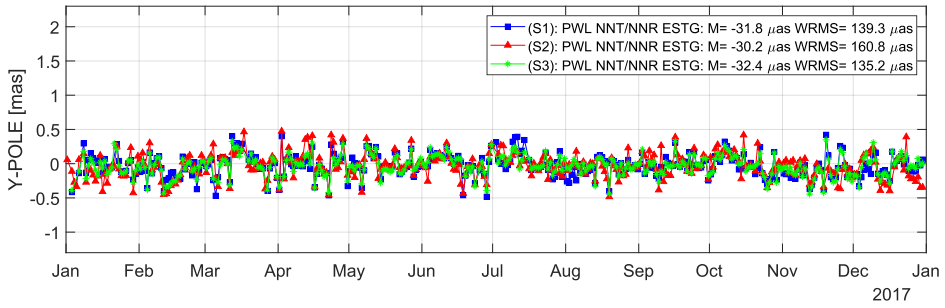
Abbreviations:

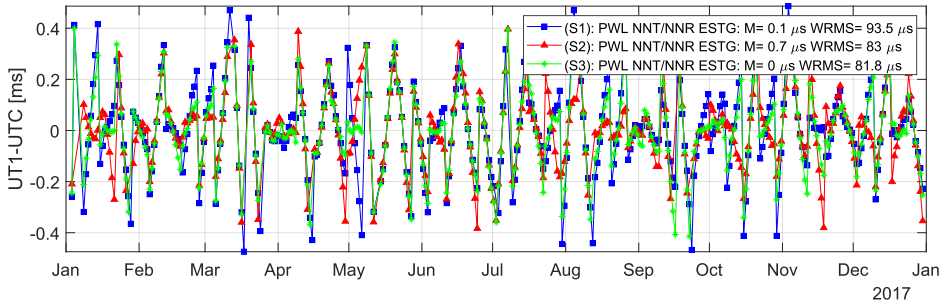
(S1): LAGEOS+ETALON (7-day arcs)

(S2): LAGEOS+ETALON+ LARES (7-day arcs)

(S3): LAGEOS+ETALON+ LARES (daily dyn. Param. for LARES)







Solutions				X pole [μas]		Y pole [μas]		UT1-UTC [μs]	
	Station coordinates	Geo-center	ERPs	Bias	WRMS	Bias	WRMS	Bias	WRMS
(S1)	NNT/NNR	est.	PWC	123.9	190.2	-26.5	169.8	-2.7	21.5
			PWL	121.7	185.3	-28.3	153.6	1.0	105.2
(S2)	NNT/NNR	est.	PWC	-51.6	187.8	-23.1	170.2	-3.0	22.9
			PWL	-53.7	175.5	-30.2	160.8	0.7	83.0
(S3)	NNT/NNR	est.	PWC	37.1	158.5	-25.1	166.7	-2.6	21.3
			PWL	32.1	146.9	-29.1	152.6	0.2	92.1

Conclusion:

Piecewise-linear parametrization of ERPs can improve the solution

SUMMARY & OUTLOOK

Outline:
- Introduction
- Analysis
- Summary and Outlook

Summary:

- We successfully included LARES with two different orbit parametrizations in our SLR solutions
- A good datum definition is needed
- Piecewise-linear parametrization of ERPs improves the quality of the ERPs

Outlook:

- Further investigations of PWL parametrization of ERPs
- Co-estimation of low-degree gravity field coefficients

REFERENCES

1. Sośnica, K.; 2015: **Determination of Precise Satellite Orbits and Geodetic Parameters using Satellite Laser Ranging**. Geodätisch-geophysikalische Arbeiten in der Schweiz, vol. 93.