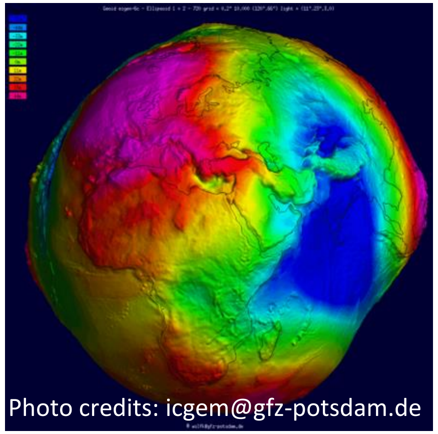
Impact of a Priori Gravity Field Models on SLR Data Processing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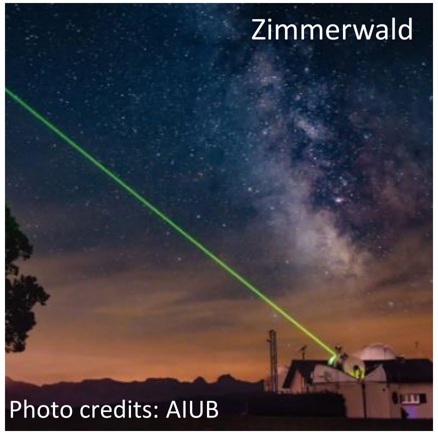

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IUGG Berlin 2023, 28th GENERAL ASSEMBLY, 17 July 2023

Outline

- Parametrization and background models used in the SLR processing
- A priori gravity field models
- Results of multi-satellite SLR combinations using LAGEOS-1/2, LARES and Starlette SLR observations
- Summary & Outlook

LAGEOS-1/2 + LARES: Parametrization + Models

Outline:
- Parametrization + Models
- A priori Gravity fields
- Results
- Summary & Outlook

Parametrization

Parametrization \ Satellites	LAGEOS-1/2 (weight 1.0)	LARES (weight 0.45)
Osculating elements	$a, e, i, \Omega, \omega, u_0$	
	1 set per 7 days	
Constant and once-per-revolution accelerations	S_0, S_S, S_C, W_S, W_C	
	1 set per 7 days	
Pseudo-stochastic pulses	no pulses	in along-track (twice per day)
Earth Rotation Parameters	$X_P, Y_P, UT1-UTC$	
	piecewise-linear	
Geocenter coordinates	1 set per 7 days	
	free geocenter	
Station coordinates	1 set per 7 days	
	NNR and NNT	
Range biases	1 set per 7 days for	
	selected stations	all stations

Background models

Models	Description
Reference frame	SLRF2014
ERP	IERS-14-C04
Nutation model	IAU2000 (Mathews et al. 2002)
Subdaily pole model	DESAI: IERS 2010
Ocean tide model	FES2014b: d/o 30 (Lyard et al. 2021) + admittances
Earth Tides	Solid earth tides, Pole tides and Ocean pole tides: IERS 2010
Loading corrections	Ocean tidal loading: FES2014 Atmospheric tidal loading: Ray and Ponte (Ray and Ponte 2003)
De-aliasing products	Atmosphere + Ocean RL06: d/o 30 incl. S1- and S2-atmosphere tides (Dobslaw et al. 2017)
Earth gravity field	GGM05S, COST-G, …. ? : d/o 90

Study the impact of a priori gravity field models on the estimation of geodetic parameters!

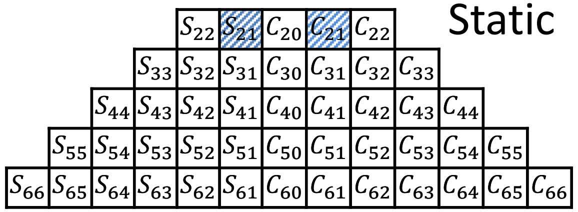
A priori gravity field models

Outline:

- Parametrization + Models
- A priori Gravity fields
- Results
- Summary & Outlook

- GGM05S (static field)

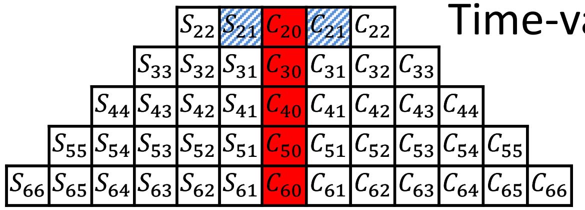
Static



- GGM05S + time-variable coefficients for the zonals $C_{20}/C_{30}/C_{40}/C_{50}/C_{60}$ and C_{21}/S_{21} provided by the ILRS

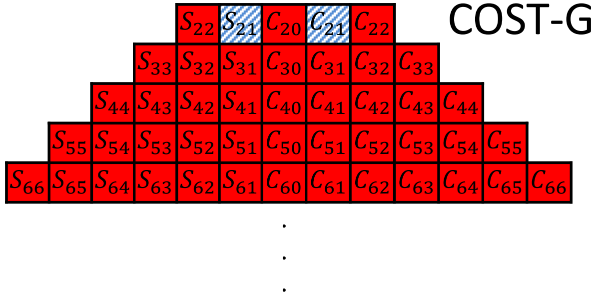
  («semi» time-variable field)

Time-var. ILRS



- COST-G (time-variable field)

COST-G



Further option: replace C_{21}/S_{21} according to the IERS2010 conventions

LAGEOS-1/2 + LARES: Results

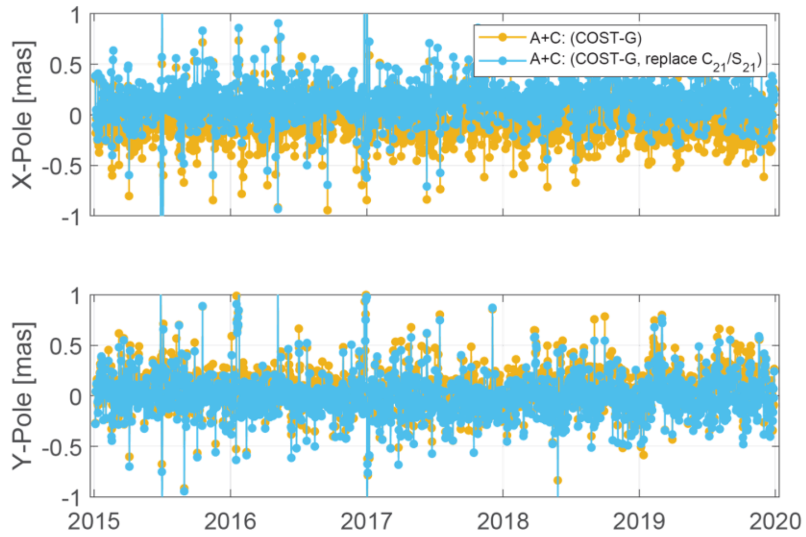
Outline:

- Parametrization + Models
- A priori Gravity fields
- Results
  - ➢ LAGEOS-1/2 + LARES
  - ➢ LAGEOS-1/2 + LARES + Starlette
- Summary & Outlook

Glossary:

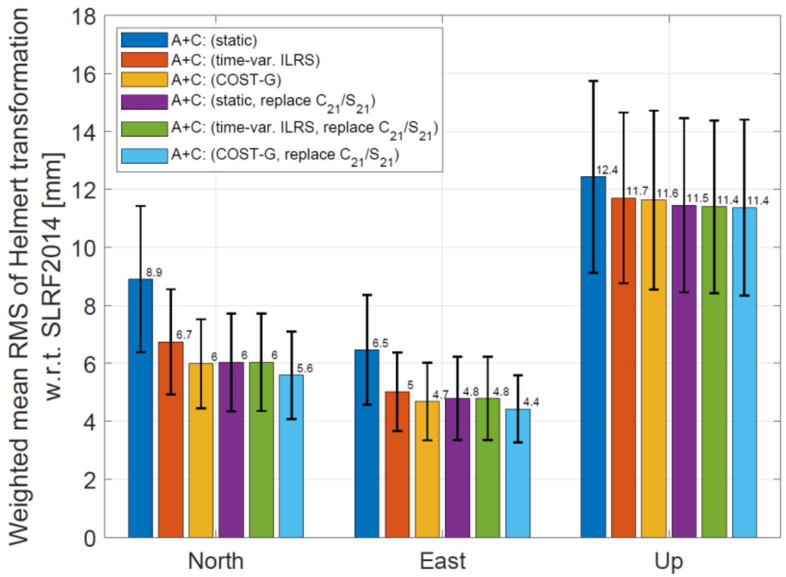
- A: LAGEOS-1/2
- C: LARES

• Earth Rotation Parameters (ERPs)



	Replace C_{21}/S_{21}	X pole $[\mu as]$		Y pole $[\mu as]$		UT1-UTC $[\mu s]$	
		Bias	WRMS	Bias	WRMS	Bias	WRMS
Static	×	-295.1	350.8	-12.5	158.7	-36.2	133.7
Static	✓	22.6	132.2	-9.8	116.9	-13.4	83.5
Time-var. ILRS	×	-86.8	166.5	38.3	146.1	-16.3	87.0
Time-var. ILRS	✓	21.1	130.6	-11.9	115.3	-12.6	81.4
COST-G	×	-74.8	148.7	60.4	136.8	-8.9	79.1
COST-G	✓	126.6	177.3	-16.0	117.6	-10.2	75.2

• Station coordinates



LAGEOS-1/2 + LARES: Results

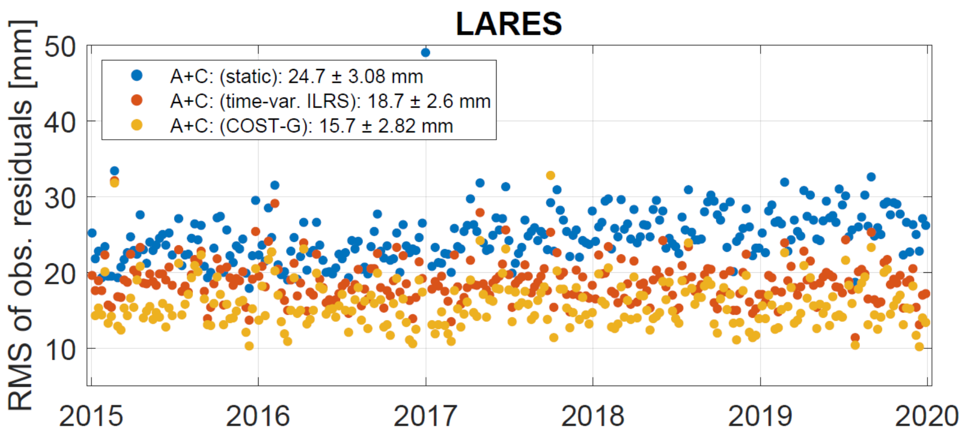
Outline:

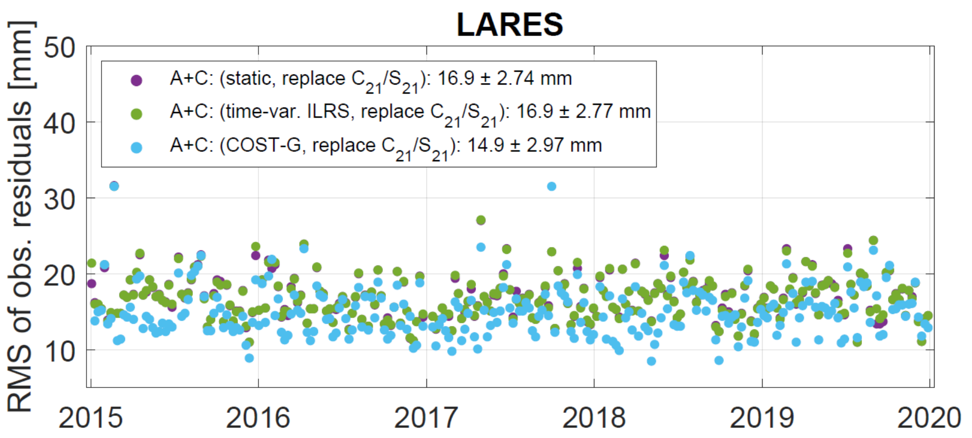
- Parametrization + Models
- A priori Gravity fields
- Results
  - ➢ LAGEOS-1/2 + LARES
  - ➢ LAGEOS-1/2 + LARES + Starlette
- Summary & Outlook

Glossary:

- A: LAGEOS-1/2
- C: LARES

- Observation residuals





- Conclusions
  - The replacement of C_{21}/S_{21} (according to the IERS2010 conventions)
    - improves the geodetic parameters: ERPs (except for X-pole if COST-G model is used), station coordinates,
    - reduces the observation residuals,

    independent of the used a priori gravity field model.
  - The use of the gravity field model provided by COST-G
    - improves some ERPs and the station coordinates,
    - reduces the observation residuals of LARES.

LAGEOS-1/2 + LARES + Starlette: Parametrization

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Outline:

- Parametrization + Models
- A priori Gravity fields
- Results
  - ➢ LAGEOS-1/2 + LARES
  - ➢ LAGEOS-1/2 + LARES + Starlette
- Summary & Outlook

Glossary:

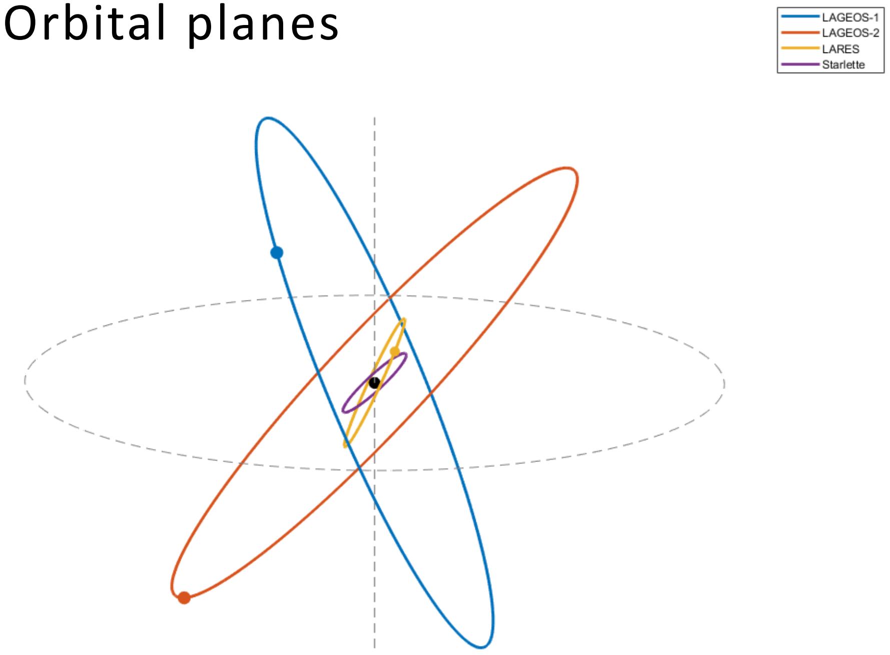
- A: LAGEOS-1/2
- C: LARES
- D: Starlette

• Parametrization

VCE

Parametrization \ Satellites	LAGEOS-1/2	LARES	Starlette
Osculating elements	$a, e, i, \Omega, \omega, u_0$		
	1 set per 7 days		
Constant and once-per-revolution accelerations	S_0, S_S, S_C, W_S, W_C		
	1 set per 7 days		
Pseudo-stochastic pulses	no pulses	in along-track (twice per day)	in along-track (twelve per day)
Earth Rotation Parameters	$X_P, Y_P, UT1 - UTC$		
	piecewise-linear		
Geocenter coordinates	1 set per 7 days		
	free geocenter		
Station coordinates	1 set per 7 days		
	NNR and NNT		
Range biases	1 set per 7 days for		
	selected stations	all stations	

• Orbital planes



	LAGEOS-1	LAGEOS-2	LARES	Starlette
Diameter [m]	0.60	0.60	0.36	0.24
Weight [kg]	407.0	405.4	386.6	47.5
Altitude [km]	5860	5620	1450	812
Inclination [°]	109.8	52.6	69.5	48.8

[1]

References:

[1] https://ilrs.gsfc.nasa.gov

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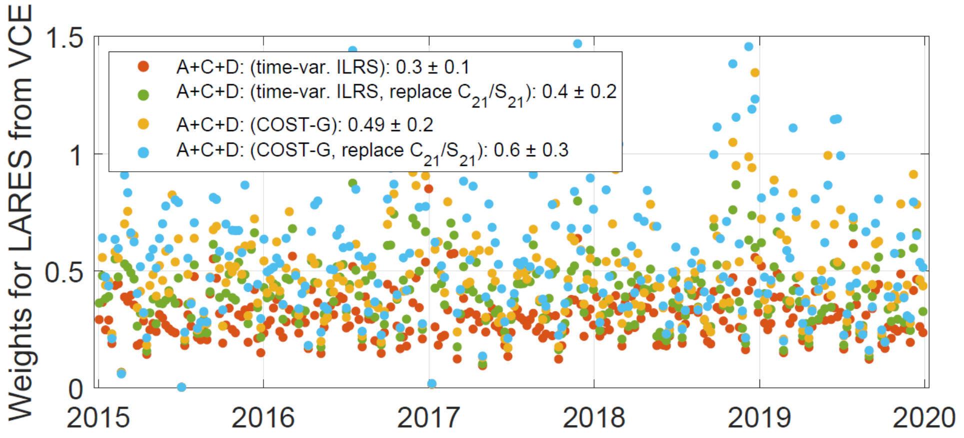
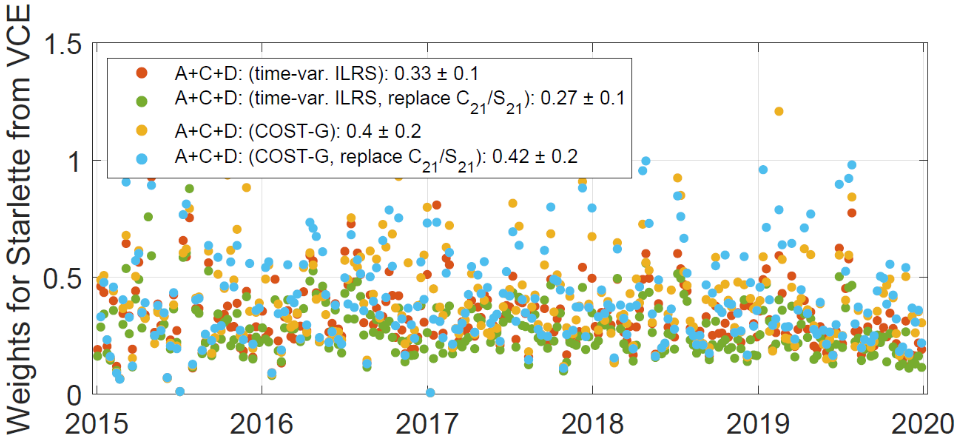
LAGEOS-1/2 + LARES + Starlette: Results

Outline:
- Parametrization + Models
- A priori Gravity fields
- **Results**
  - ➢ LAGEOS-1/2 + LARES
  - ➢ **LAGEOS-1/2 + LARES + Starlette**
- Summary & Outlook

Glossary:
- A: LAGEOS-1/2
- C: LARES
- D: Starlette

• Weights per satellite

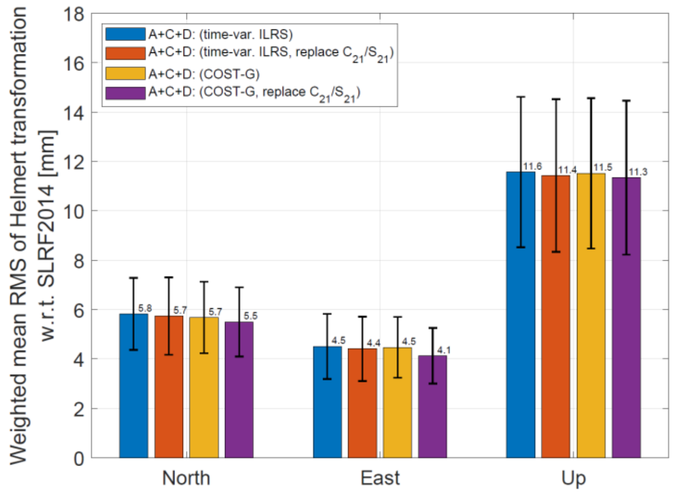




• Earth Rotation Parameters

	Replace C_{21}/S_{21}	X pole $[\mu as]$		Y pole $[\mu as]$		UT1-UTC $[\mu s]$	
		Bias	WRMS	Bias	WRMS	Bias	WRMS
Time-var. ILRS	×	19.8	128.0	47.7	134.3	-8.3	73.2
Time-var. ILRS	✓	89.1	150.0	0.5	112.5	-9.5	73.1
COST-G	×	-70.8	150.5	59.7	143.9	-11.1	80.1
COST-G	✓	145.3	193.3	-33.0	129.8	-6.0	71.7

• Station coordinates



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LAGEOS-1/2 + LARES + STARLETTE: RESULTS

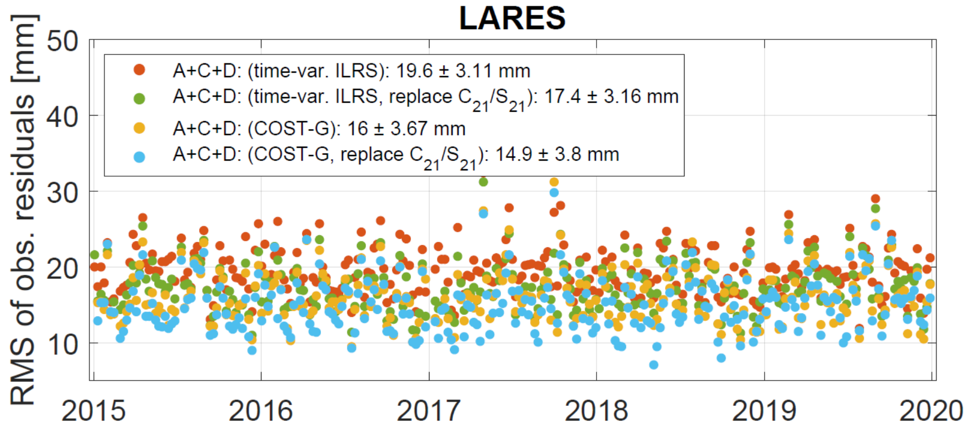
Outline:

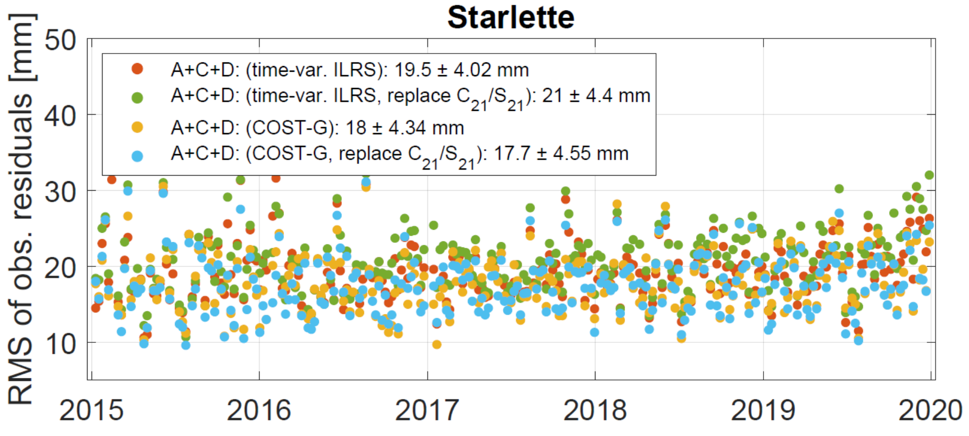
- Parametrization + Models
- A priori Gravity fields
- Results
  - ➢ LAGEOS-1/2 + LARES
  - ➢ LAGEOS-1/2 + LARES + Starlette
- Summary & Outlook

Glossary:

- A: LAGEOS-1/2
- C: LARES
- D: Starlette

- Observation residuals





- Conclusions
  - LARES and Starlette receive from the VCE the highest weights if the COST-G model is used.
  - The replacement of C_{21}/S_{21} (according to the IERS2010 conventions)
    - has a major impact on the weights of LARES,
    - downgrades the X-pole, while the Y-pole is improved

  independent of the used a priori gravity field model.

SUMMARY & OUTLOOK

Outline:
- Parametrization + Models
- A priori Gravity fields
- Results
  - LAGEOS-1/2 + LARES
  - LAGEOS-1/2 + LARES + Starlette
- Summary & Outlook

- Summary:
  - The a priori gravity field model has an impact on the estimated geodetic parameters of SLR analyses.
  - The COST-G model can (should) also be used in the SLR processings.
- Outlook:
  - Study the impact of the a priori gravity field model when the low-degrees are co-estimated.

SUMMARY & OUTLOOK

Outline:

- Parametrization + Models
- A priori Gravity fields
- Results
  - LAGEOS-1/2 + LARES
  - LAGEOS-1/2 + LARES + Starlette
- Summary & Outlook

Thank you for your attention!