Contribution of SLR to satellite-only global gravity field model

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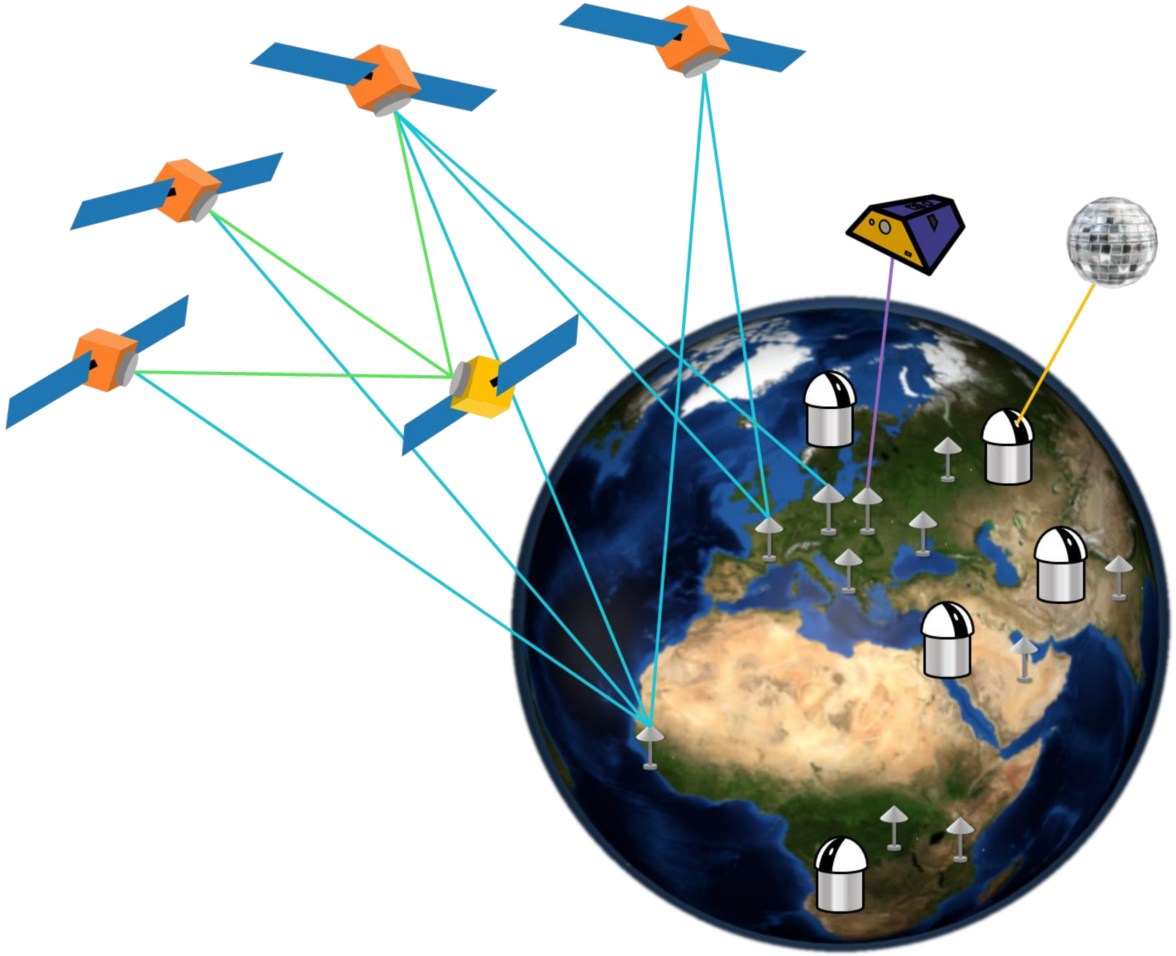
Combined satellite-only global gravity field models

Advantage: Compensates for the weaknesses of individual observation techniques.

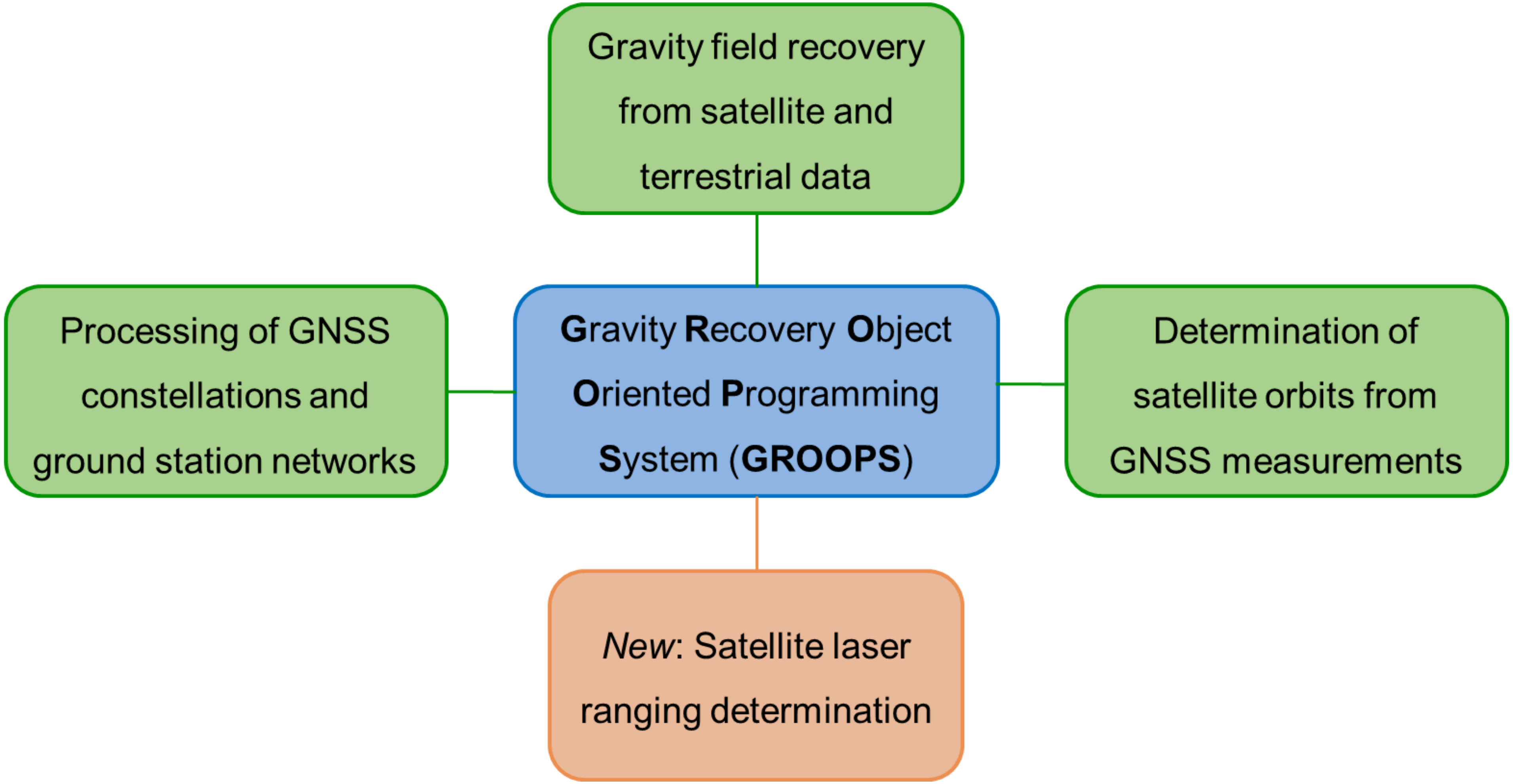
Issue: The combination of solutions from different institutions can have an impact on the performance due to the use of different methods and algorithms.

Goal: Consistent computation of the next Gravity Observation Combination (GOCO) model.



Software toolkit GROOPS

Perform all evaluations with a uniform software package!



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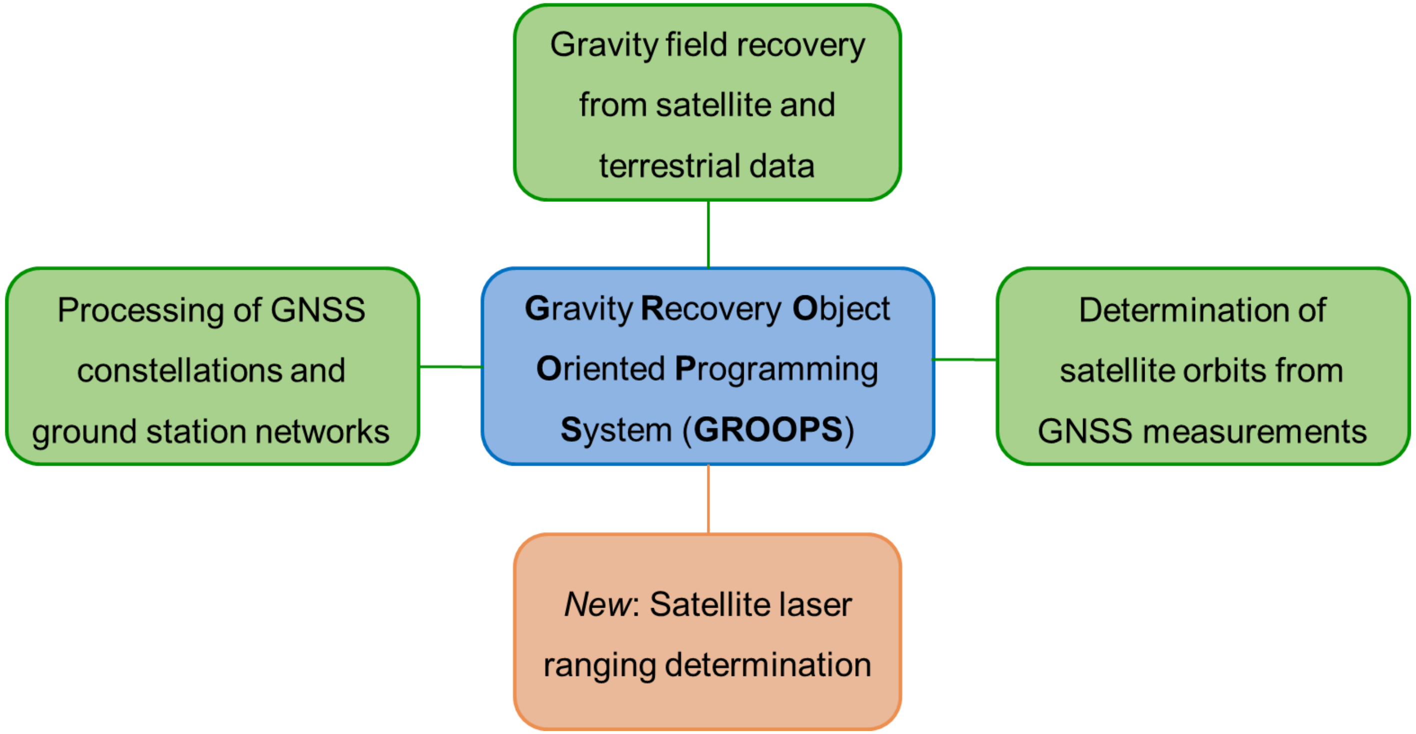

Available at GitHub

https://github.com/groops-devs/groops

(Mayer-Guerr et al., 2021)

GROOPS

Gravity field coefficients estimation – Process flow in GROOPS

- Orbit integration using the given forces (State-of-the-art models, e.g. AOD1B-RL06, GOCO06s…) → Integral Equation appr.

  program PreprocessingVariationalEquation

- Fit the integrated orbit to initial orbit positions (e.g. CPF provided by ILRS…)

  program PreprocessingVariationalEquationOrbitFit

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- Process weekly SLR NP or FR observations and estimate the dynamic orbit positions, station range bias and gravity field coefficients (stored in a normal equation system). Using VCE for stations weighting and outlier detection.

program SlrProcessing

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- Accumulate to a monthly normal system and solve it. Using VCE for relative weighting between the individual normals.
  - program NormalsAccumulate
  - program NormalsSolverVCE
- Evaluate the time variable gravity field and save it as spherical harmonics
  - program Gravityfield2PotentialCoefficients

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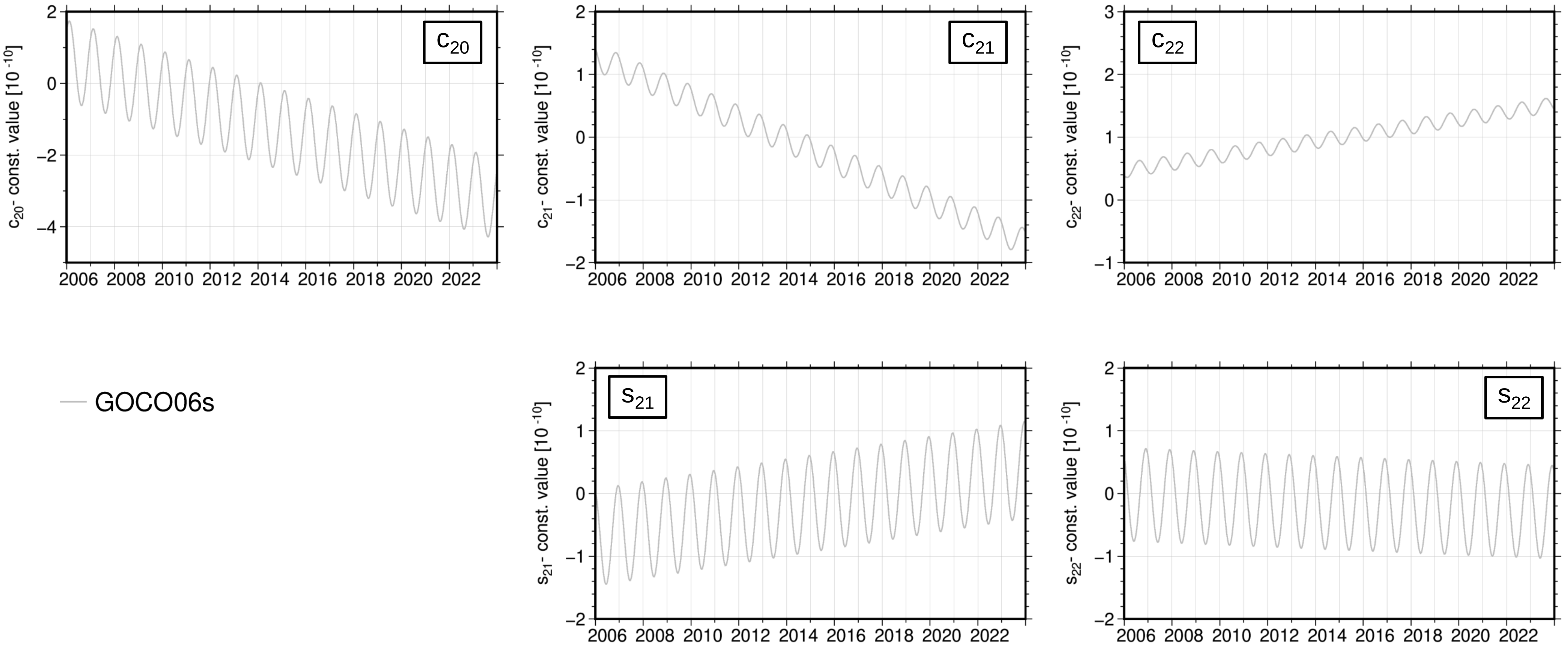
Gravity field coefficients estimation – Settings

Using state-of-the-art force models and following further settings:

Satellites	Ajisai, LAGEOS-1/2, Starlette and Stella
Station coordinates	ITRF2020
Tropospheric refraction model	Mendes & Pavlis
Center of mass corrections	1.01 m (Ajisai), 0.251 m (LAGEOS-1/2), 0.075 m (Stella, Starlette)
Normal points weighting	yes
Arc	~ 7 days
Estimated arc parameters:	
• Atmospheric drag coefficient	Once per day (constant bias for along and cross)
• Empirical accelerations	Once per revolution (sin, cos) along track
• Station range bias	Once per arc
• Satellite state vector	Once per arc
• Gravity field coefficients	Per arc, up to spherical harmonic degree and order 5, and c_{61}, s_{61}

Results: Time variable part degree 2 coefficients



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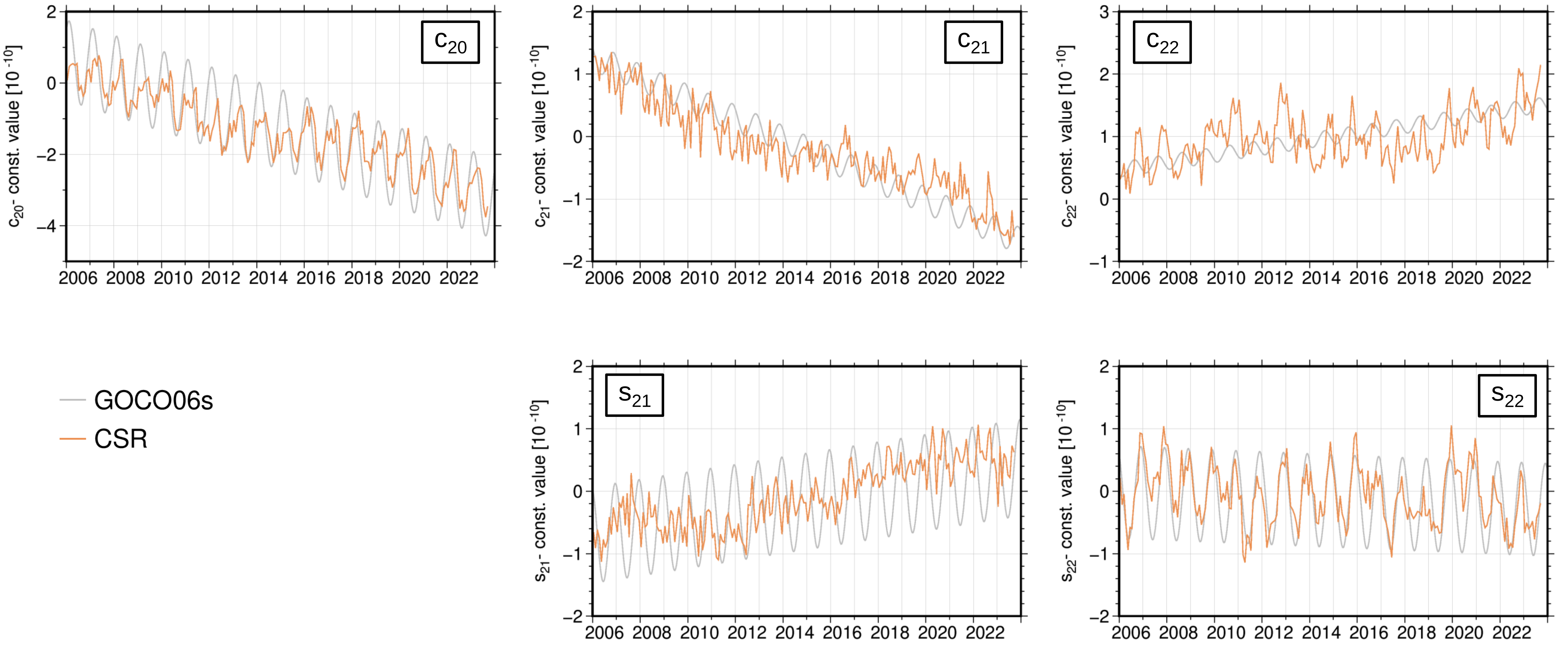

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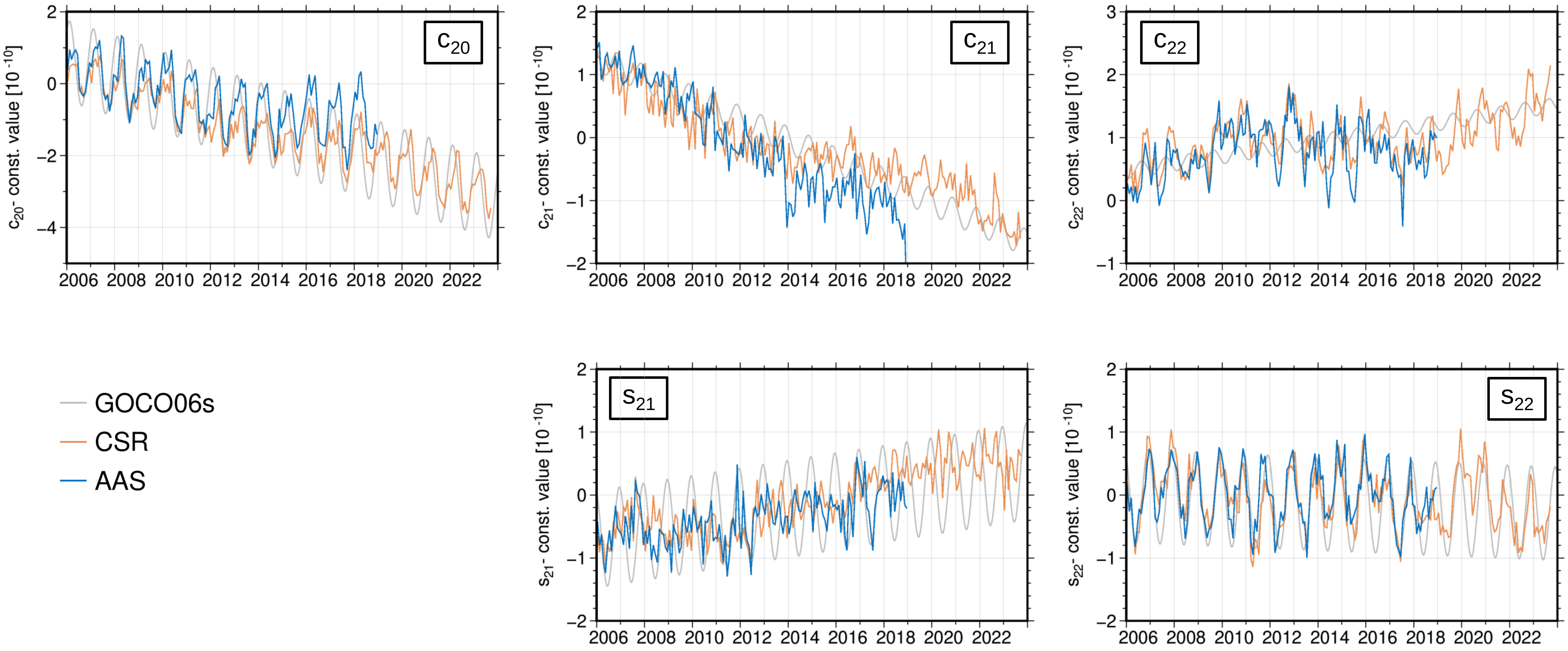

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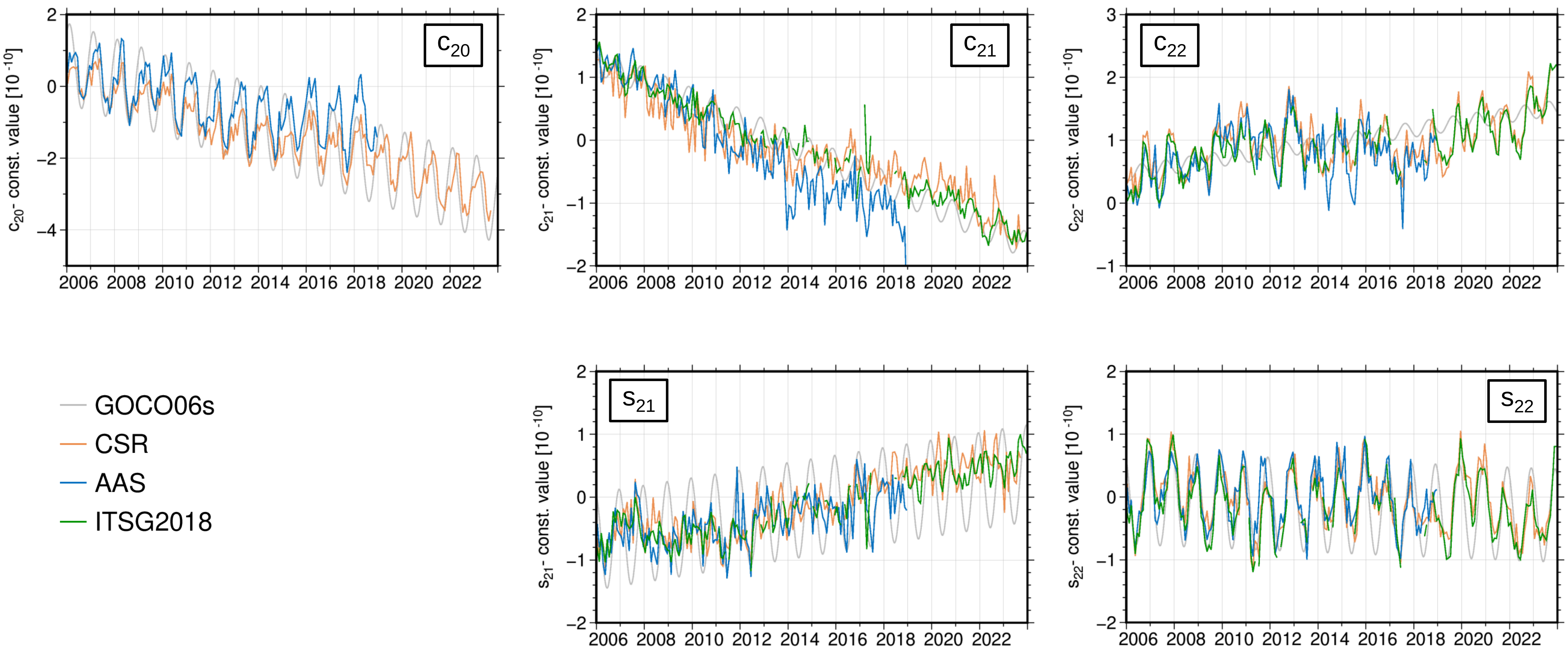
Results: Time variable part degree 2 coefficients



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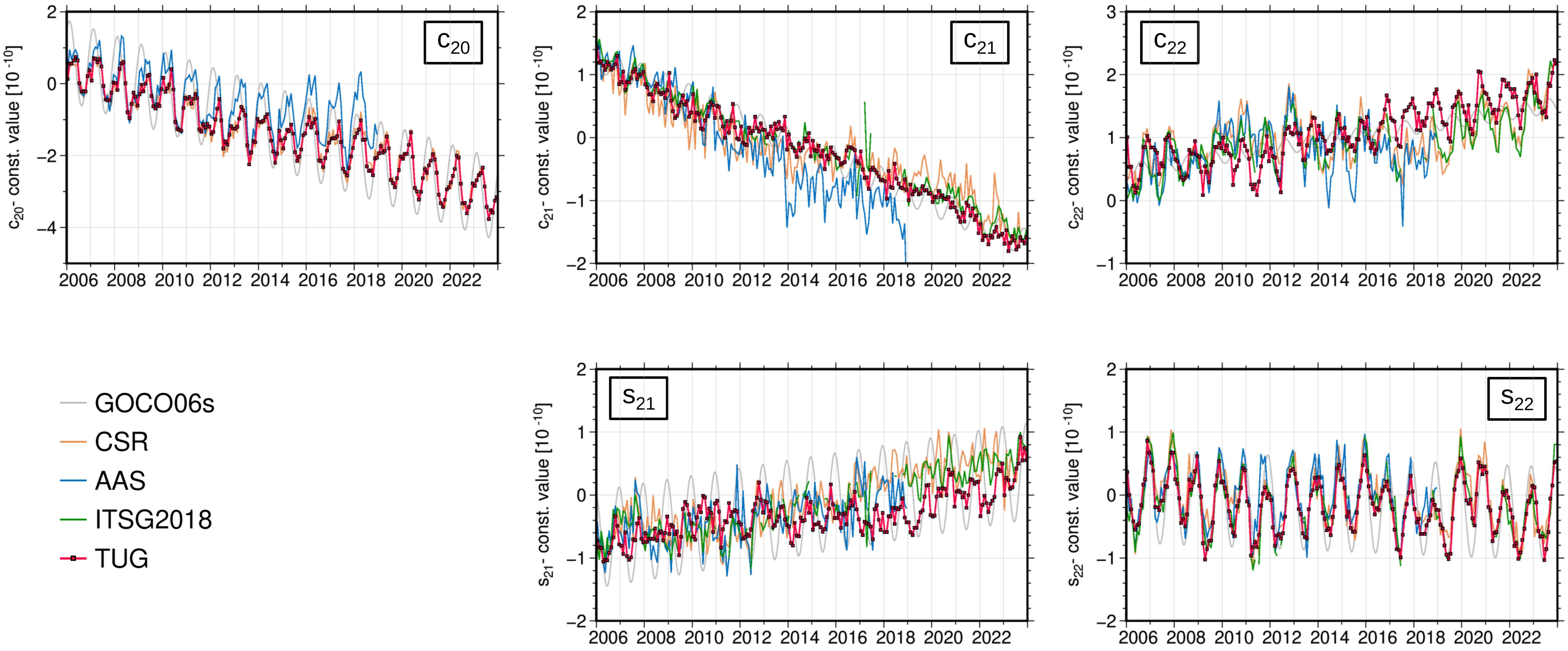

Summary, Outlook & Acknowledgement

Summary

- Extended the functionality of GROOPS by the feature satellite laser ranging (SLR).
- Utilisation of state-of-the-art models.
- Results of the time variable part degree 2 coefficients are promising and show similar behaviour to Centre for Space Research (CSR) and Austria Academy of Science (AAS) solutions.

Outlook

- We plan to release the GROOPS source code with the SLR functionality in the next few weeks.
- Consistently computation of the next Gravity Observation Combination (GOCO) model.

Acknowledgement

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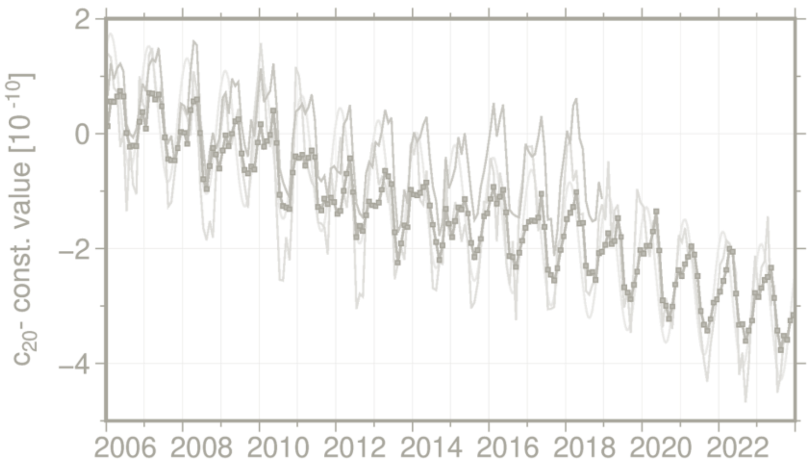
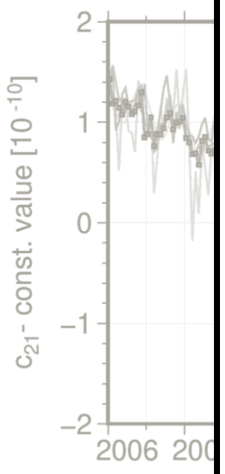
Thank you!

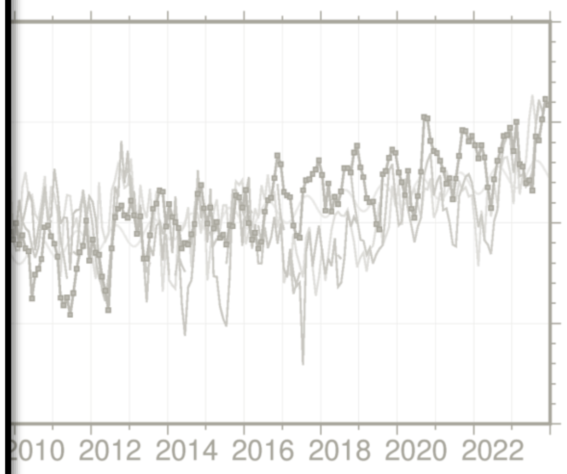
Additional Slides (1)

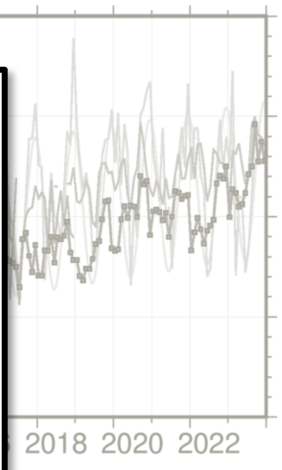




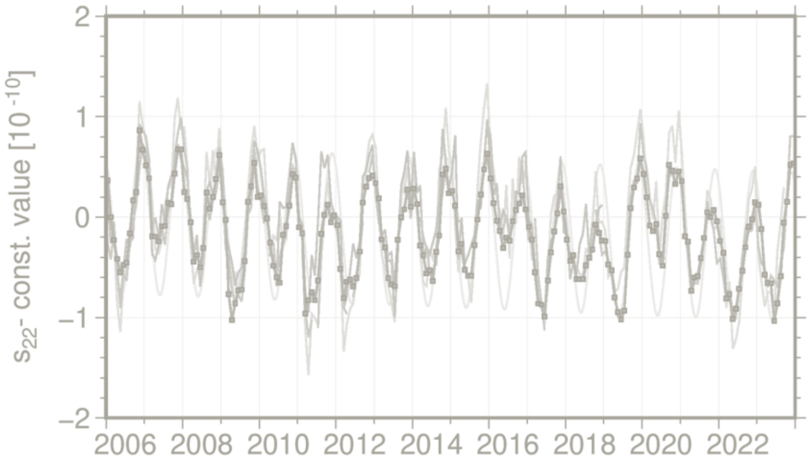
Constant values

c_{20}	-4.841694723127e-4
c_{21}	-4.0e-10
s_{21}	1.5e-9
c_{22}	2.4393e-6
s_{22}	-1.4003e-6





- GOCO06s (Kvas et al., 2021; Kvas et al., 2019)
- CSR (Cheng et al., 2013)
- AAS (Krauss et al., 2019)
- ITSG2018 (Kvas et al., 2019; Mayer-Guerr et al., 2018)
- TUG



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Additional Slides (2)

Force models

Static gravity field + annual + trend	GOCO06s
Atmosphere + ocean de-alising, atmospheric tides	AOD1B-RL06
Astronomical tides	JPL DE432
Earth tides, pole tides, relativistic effects	IERS2010
Ocean tides	FES2014b
Ocean pole tides	Desai 2004
Atmospheric density model	DTM2020
Earth radiation pressure	Albedo and long wave flux