Copernicus POD Service

Copernicus Sentinel-3 POD with COST-G

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7th Sentinel-3 Validation Team Meeting, ESRIN, Italy
18-20 October 2022

Agenda

1. **Introduction**
2. **Reprocessing**
3. **Results**
4. **Next Steps and Conclusions**

INTRODUCTION

INTRODUCTION

WHAT IS COST-G?

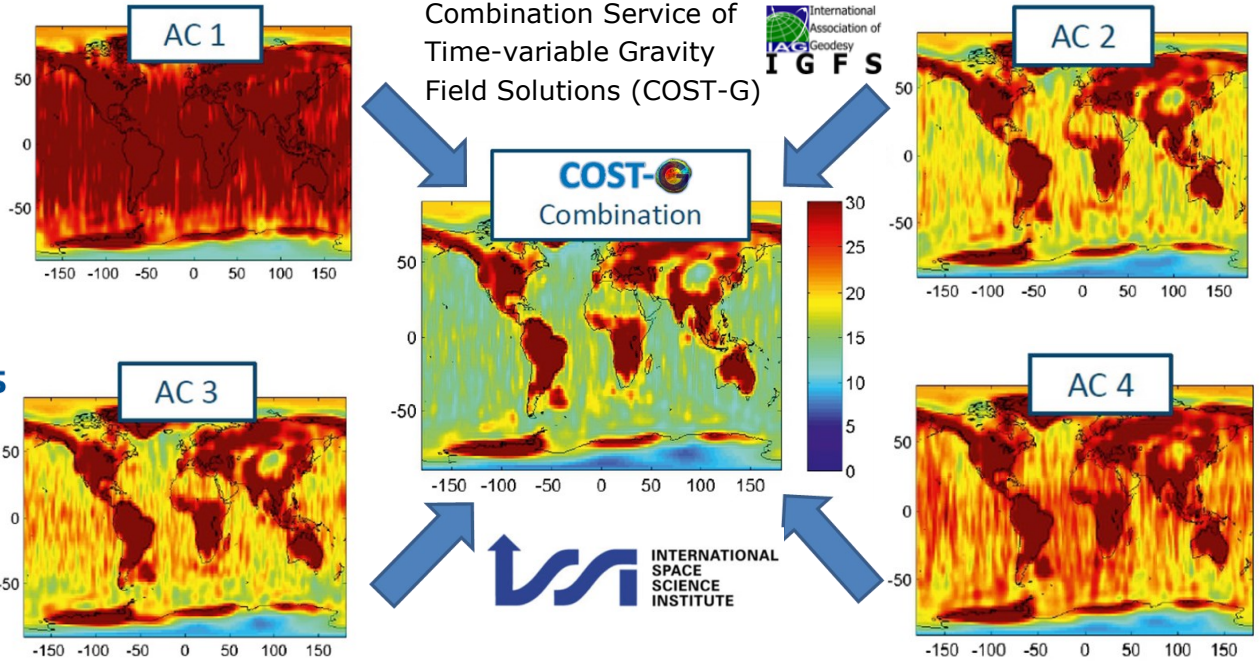
COST-G: Combination Service for Time-variable Gravity Models

4 Analysis Centres
1 Analysis Centre Coordinator
2 Partner Analysis Centres

AIUB
GFZ Helmholtz Centre Potsdam
AIUB
cnes
TU Graz
AIUB
CSR
JPL Jet Propulsion Laboratory California Institute of Technology

Combination Service of Time-variable Gravity Field Solutions (COST-G)

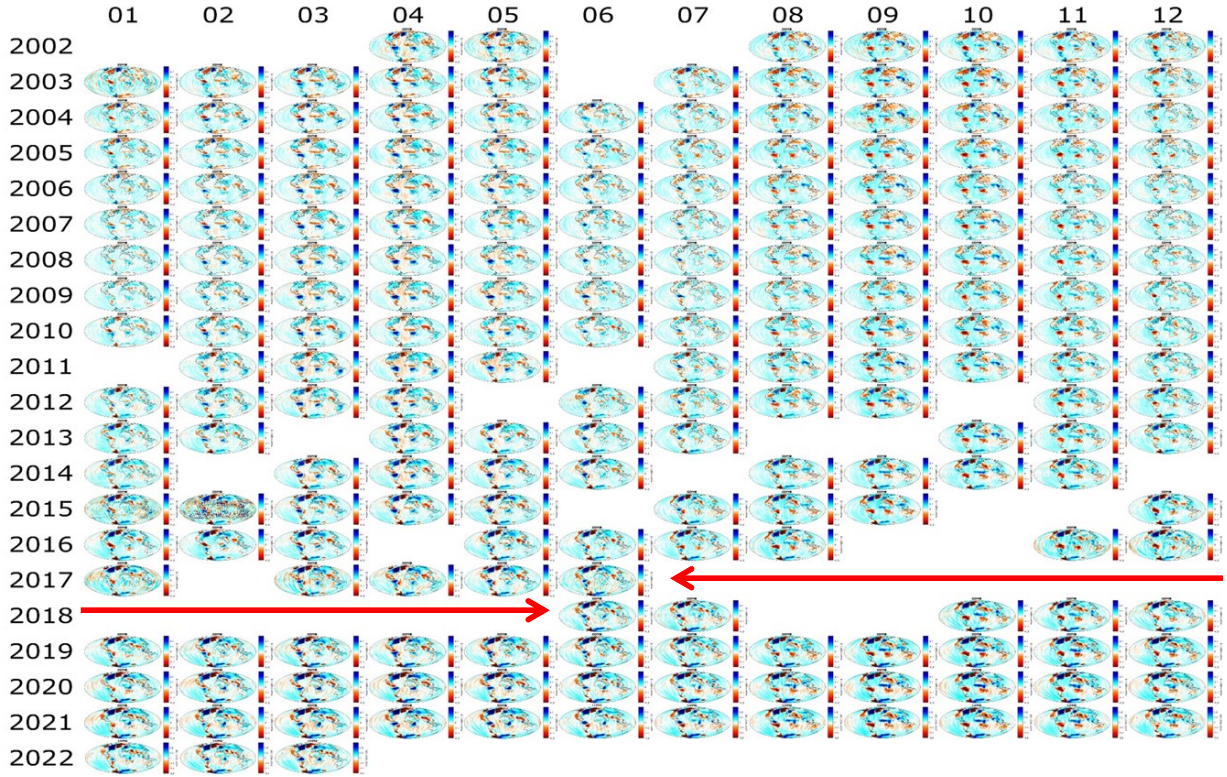
International Association of Geodesy IGFS



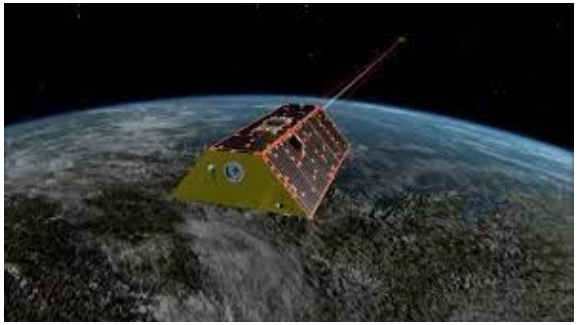
Improved and consolidated product integrating the strengths of all ACs

INTRODUCTION

GRACE-FO OPERATIONAL COMBINED MONTHLY GRAVITY FIELDS



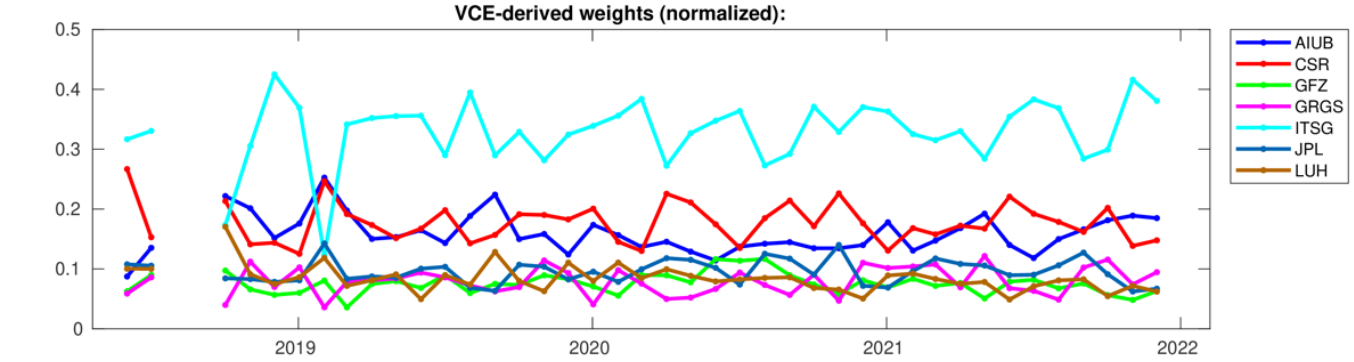
Flawless and uninterrupted operational combination with a latency < 3 months.

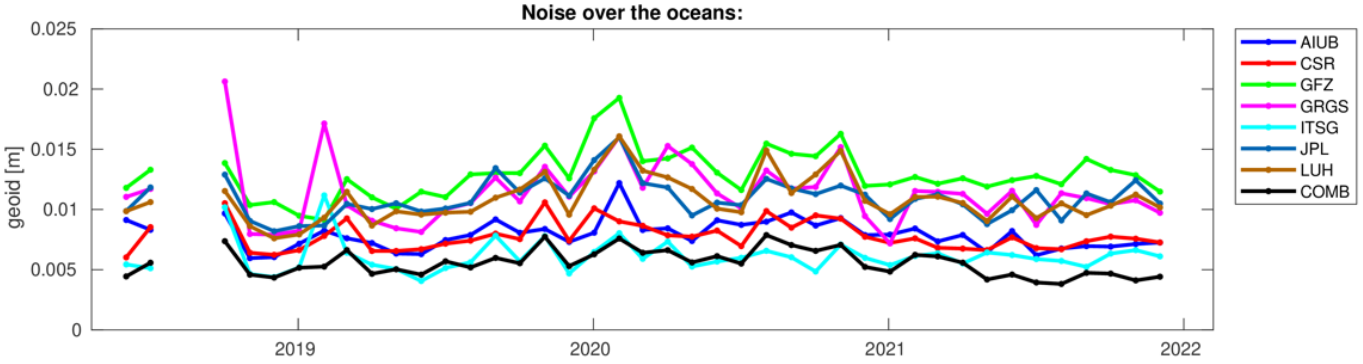


End of GRACE, beginning of GRACE-FO

INTRODUCTION

WEIGHTED COMBINATION AND VALIDATION OF THE COMBINED SOLUTION

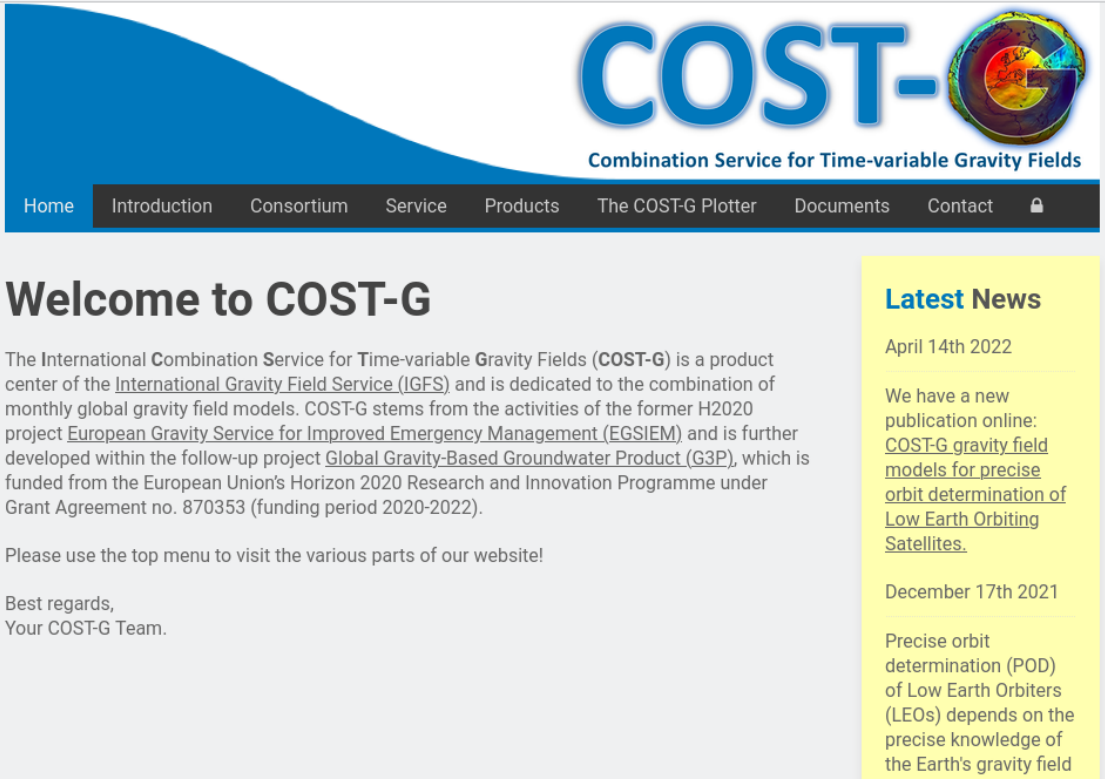




Combination outperforms all individual solutions in 2021

INTRODUCTION

COST-G

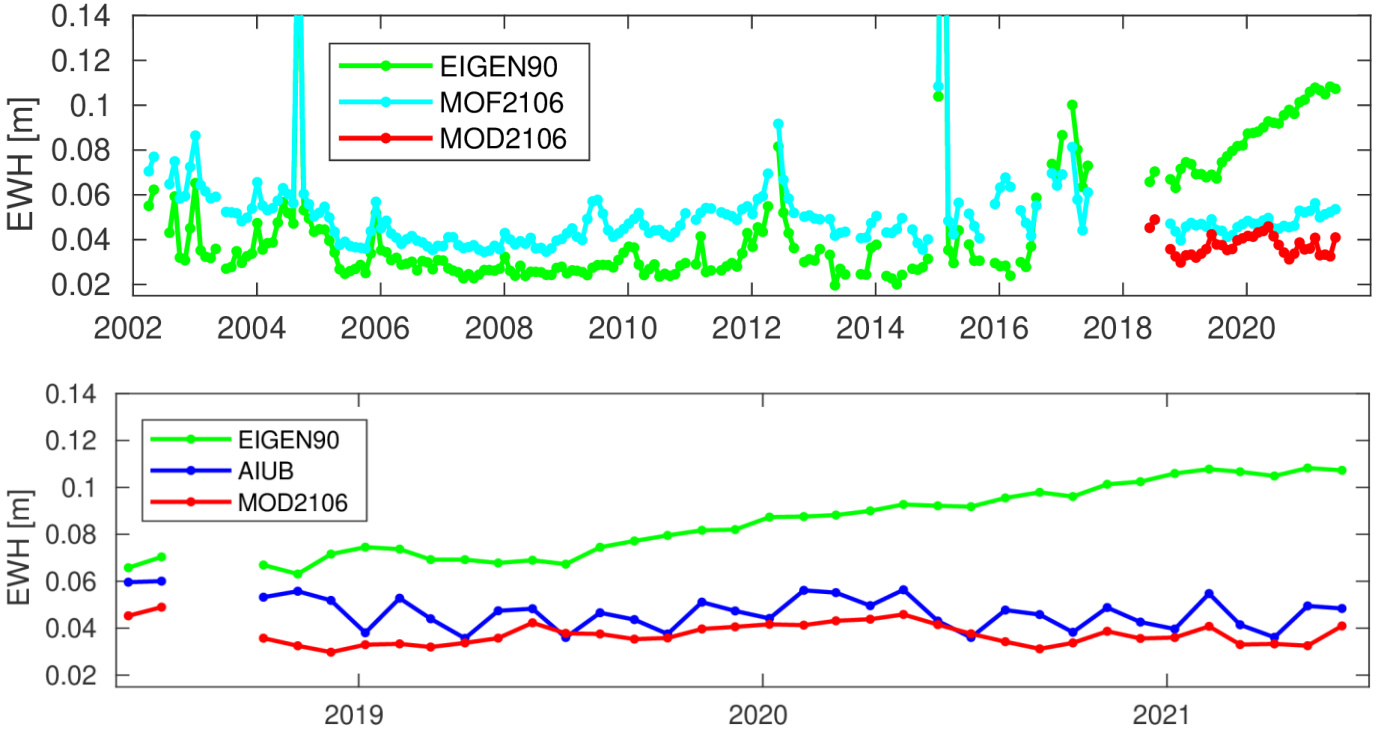


For background information on COST-G and links to products check at: https://cost-g.org

Peter H, Meyer U, Lasser M, Jäggi A (2022): *COST-G gravity field models for precise orbit determination of Low Earth Orbiting Satellites.* Advances in Space Research (69), **12**, 4155-4168.
doi: 10.1016/j.asr.2022.04.005

INTRODUCTION

EFFECT OF NEW MODEL



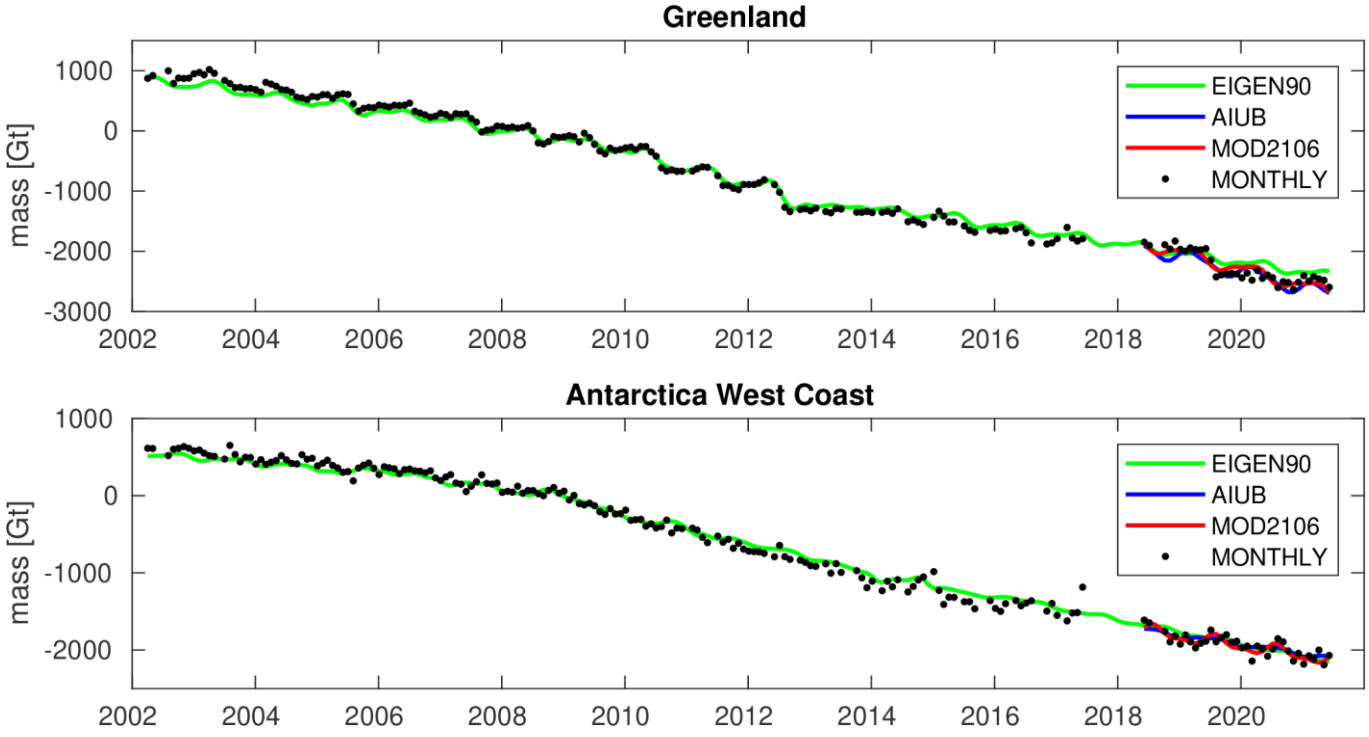
Operational precise orbit determination (POD) of Low Earth Orbiters (LEO) relies on a Earth gravity model including time-variable gravity (TVG).

The EIGEN-GRGS-RL04 model (green) has been the standard for LEO-POD of altimeter satellites, but the extrapolation to the GRACE-FO period reveals large prediction errors.

For comparison, a model fitted to COST-G GRACE-FO gravity fields is shown (red).

INTRODUCTION

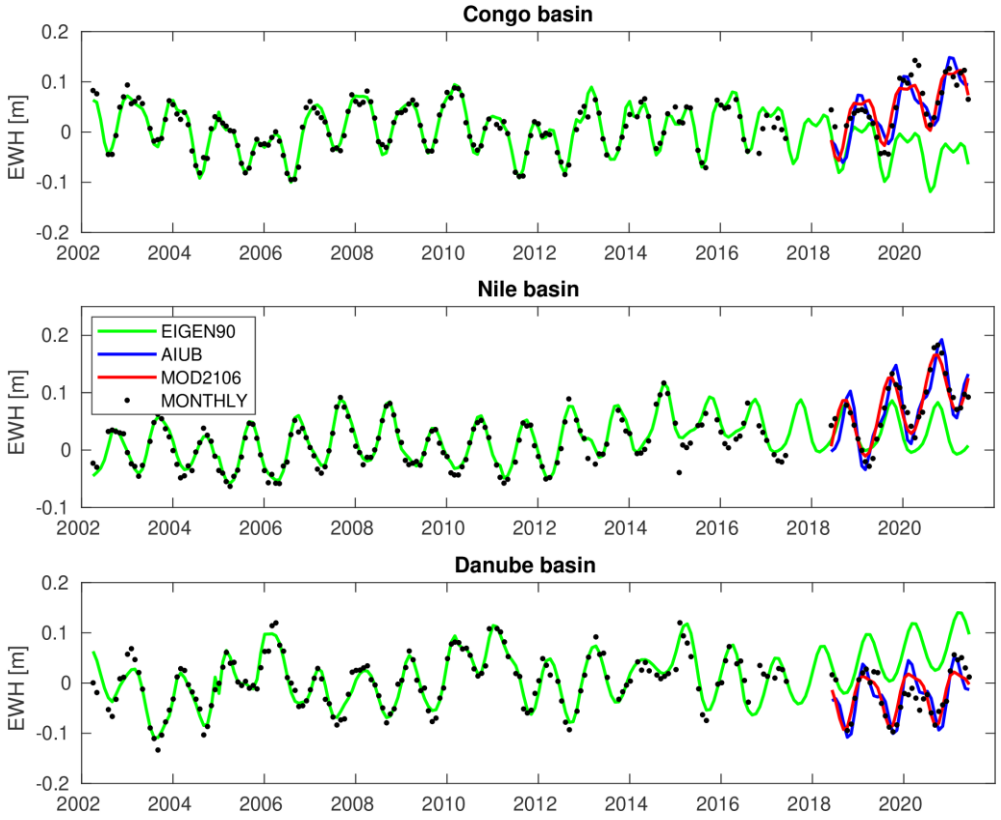
POLAR MASS TREND (NO FILTER)



Surprisingly, the reason for the prediction error in the EIGEN-GRGS-RL04 model (green) seems not to be in regions with strong mass trends.

INTRODUCTION

HYDROLOGICAL CYCLE IN LARGE RIVER BASINS (300 KM GAUSS)



The time-series of monthly GRACE gravity field solutions was fitted in yearly batches for the EIGEN-GRGS-RL04 model.

While the fit in the GRACE period is very good, the **extrapolation of the last of these batches leads to large errors in river basins** with strong non-seasonal variations.

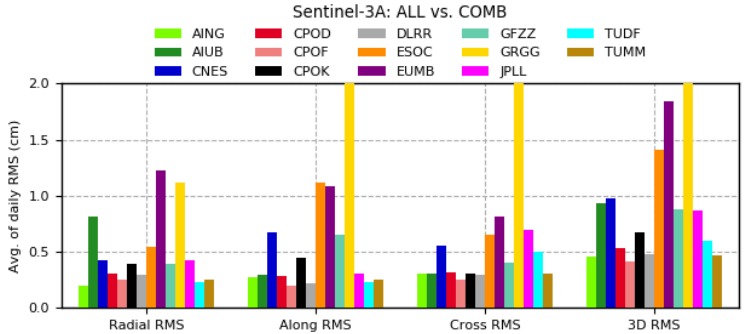
REPROCESSING

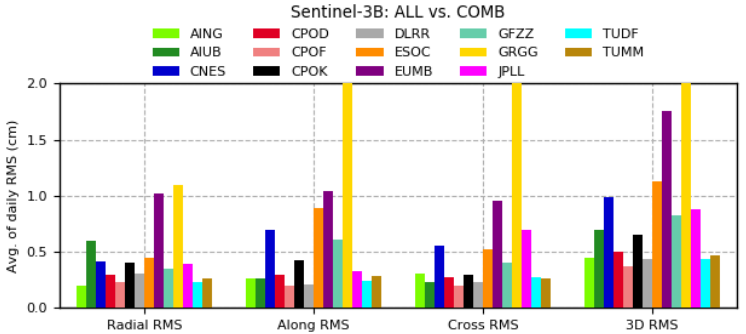
REPROCESSING

INTRODUCTION

- Initial assessment of the impact of using COST-G in the CPOD Service
  - Impact on accuracy
  - Impact on empirical accelerations

- Latest Regular Service Reviews (RSR) have showed that it provides one of the best solutions





- Reprocessing is limited to the time limits of the COST-G geopotential, currently from 2018 onwards. For the moment it is not possible to do a complete reprocessing covering years prior to 2018.

REPROCESSING

SENTINEL-3 POD MODELLING

Model	Value
EOPs	IERS rapid / finals
Reference System	IERS standards
Gravity field	EIGEN: EIGEN.GRGS.RL04 TVG COST-G: COSTG _2206
Solid tides	IERS 2010
Ocean tides	FES 2014
Atmospheric gravity	GFZ AOD L1B RL06
Earth / Ocean pole tides	IERS 2010
Radiation pressure model	Box-wing
Earth radiation	Albedo and infra-red applied
Atmospheric density model	msise00

Parameter	Value
Arc length	5+24+3 h (32h)
Drag coefficient	1 (estimated)
Solar pressure coeff.	1 (fixed)
1/rev empiricals (estimated)	16 sets per arc in: along cnt+sin+cos cross cnt+sin+cos
GNSS sampling	10 sec
GNSS products	CODE Repro (<2020) CODE Rapid (> 2020)
GNSS Clocks rate	5 sec (<2020) 30 sec (>2020)
Receiver ambiguities	Fixed
Manoeuvres	Estimated

INTRODUCTION TO CPOD SERVICE

QUALITY WORKING GROUP – COMBINED SOLUTION

AIUB | CNES | CPOD | ESOC | DLR | GFZ | TUM | TU Delft | EUMETSAT | CLS | JPL | GSFC

1st Step: Unweighted Mean

$$\mathbf{SV}_{comb\_0}(t^*) = \frac{\sum_j \mathbf{SV}_j(t^*)}{\sum_j 1}$$

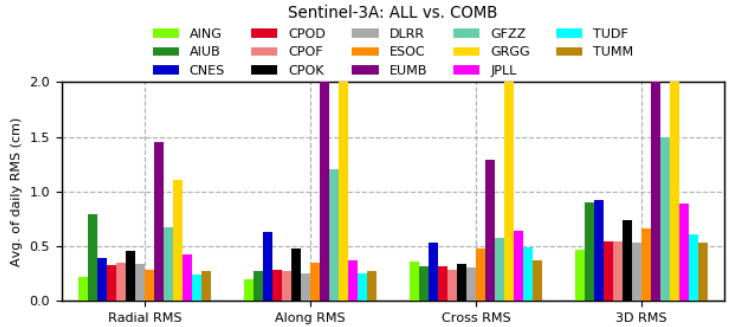
2nd Step: Daily weights as median of distances

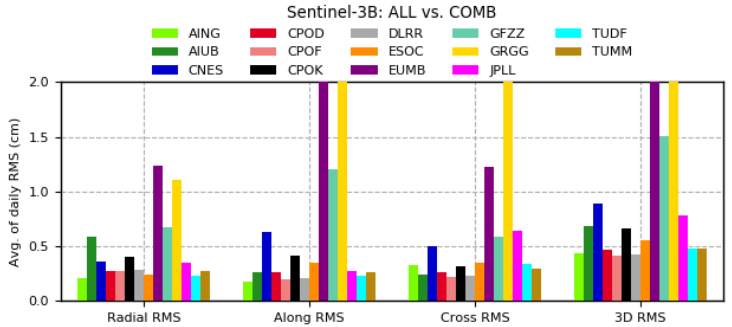
$$w_j = median \left| \boldsymbol{SV}_{comb\_0}(t^*) - \boldsymbol{r}_j(t^*) \right|$$

2nd Step: Weighted Mean

$$\mathbf{SV}_{comb}(t^*) = \frac{\sum_j \mathbf{SV}_j(t^*)/w_j}{\sum_j 1/w_j}$$

Q1 2022

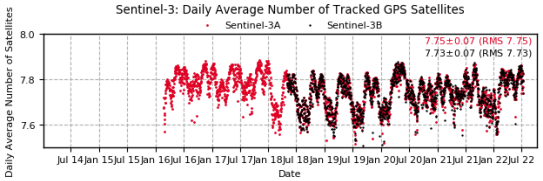




RESULTS

RESULTS

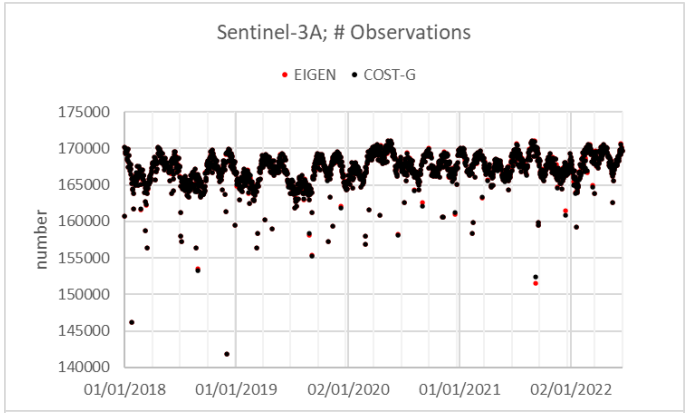
SENTINEL-3A PROCESSING METRICS

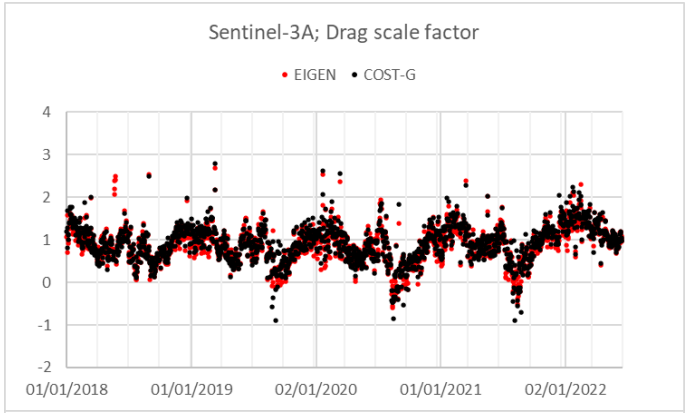


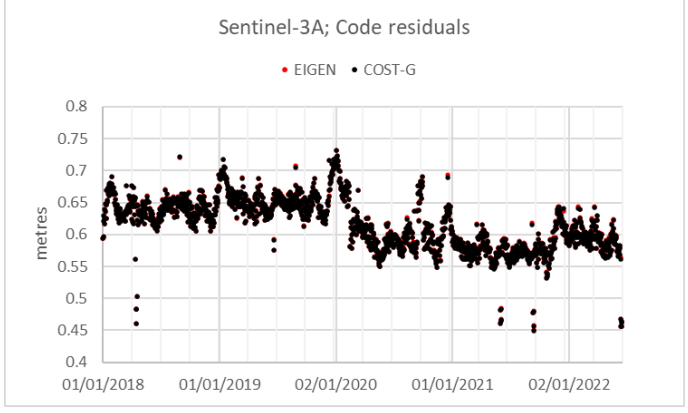
COPERNICUS POD Service

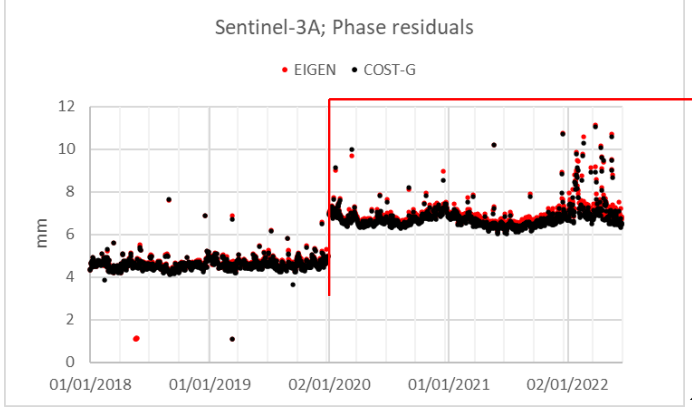
Copernicus Europe's eyes on Earth

esa





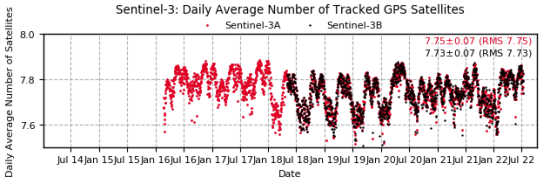


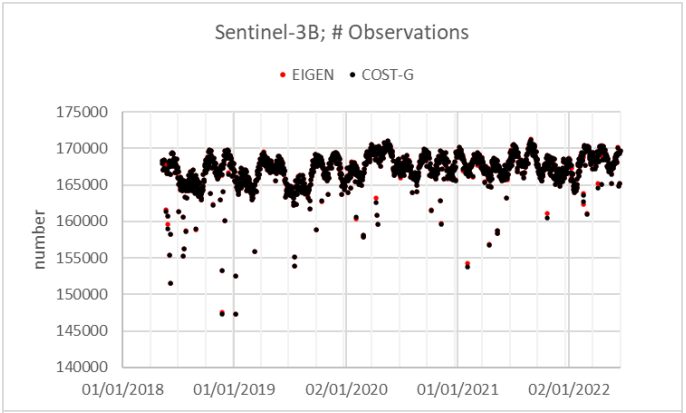


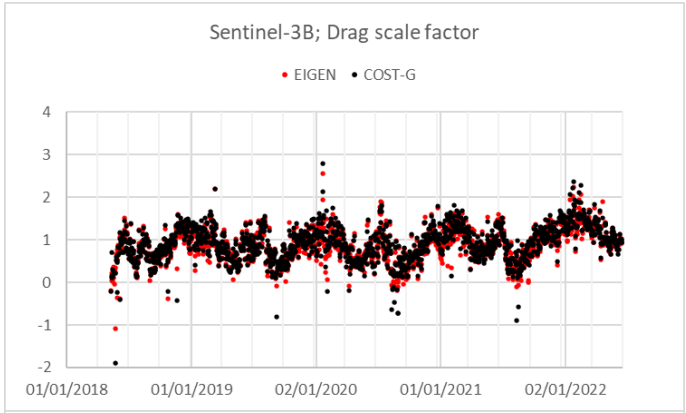
GNSS clock rate change: 5 -> 30 sec

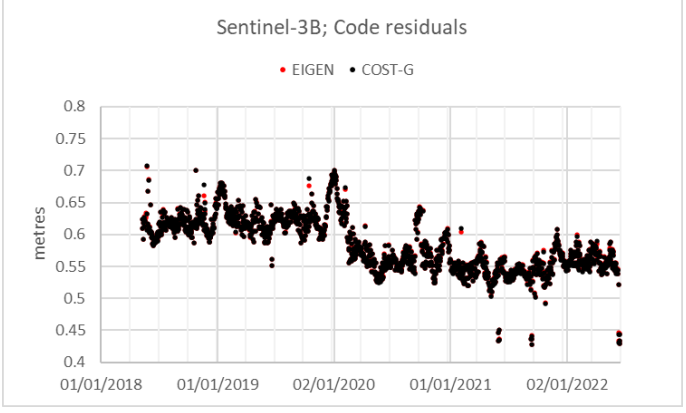
RESULTS

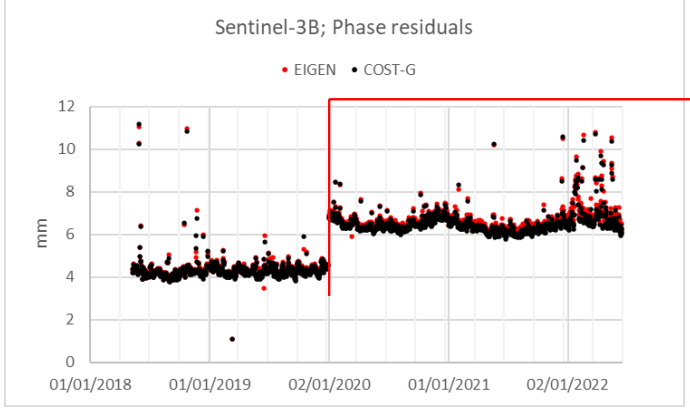
SENTINEL-3B PROCESSING METRICS







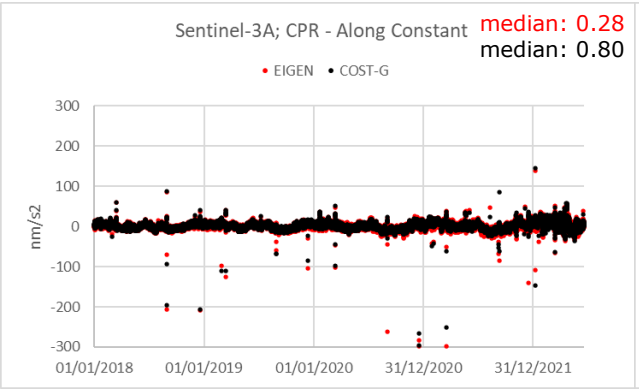


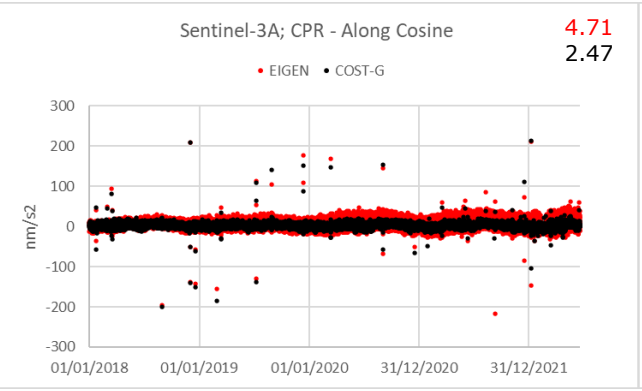


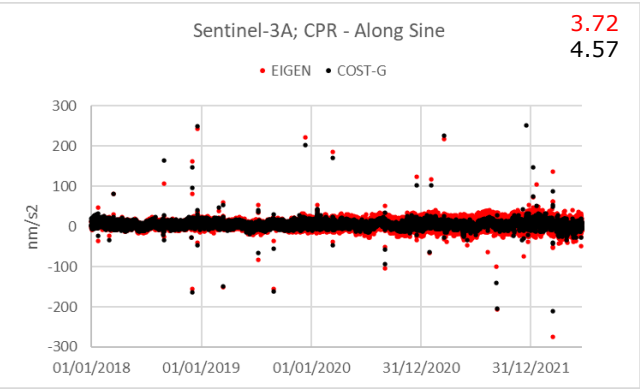
GNSS clock rate change: 5 -> 30 sec

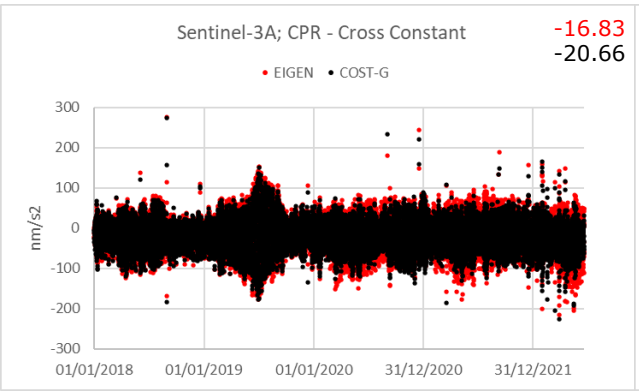
RESULTS

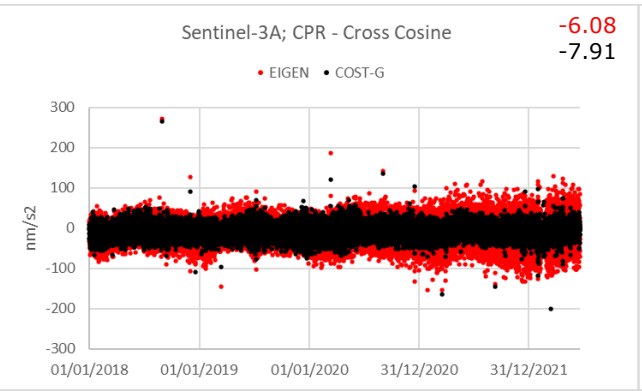
SENTINEL-3A CONSTANT PER REVOLUTION

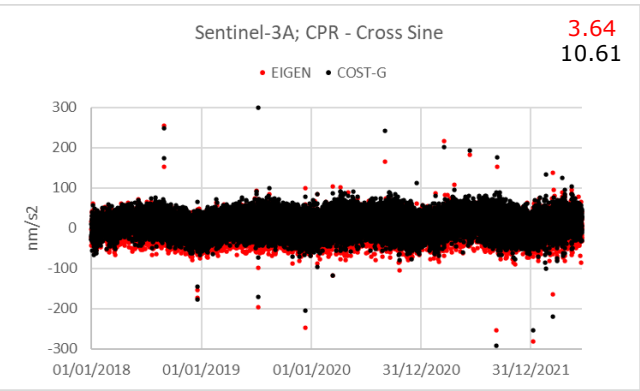






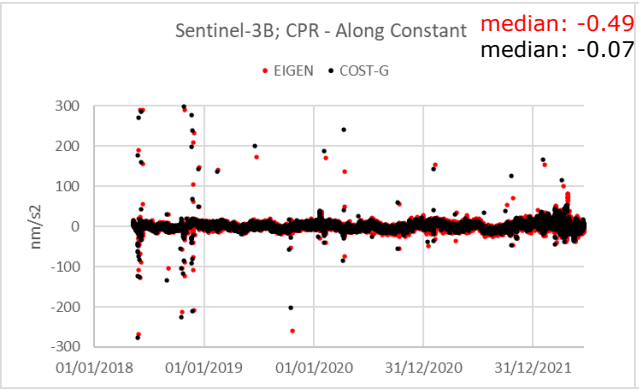


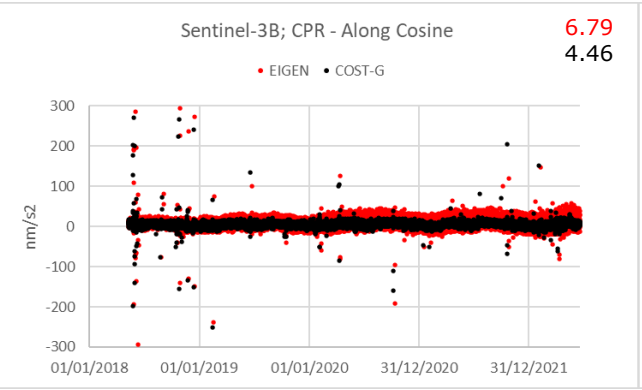


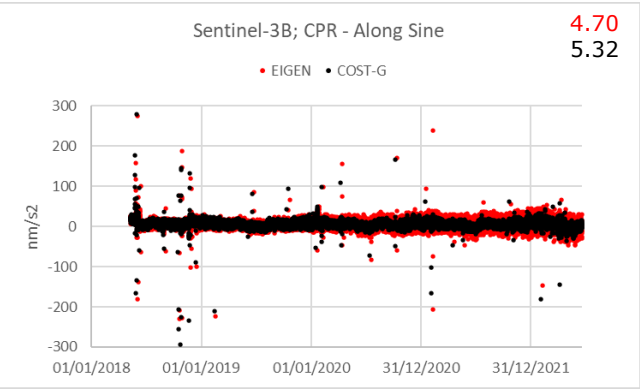


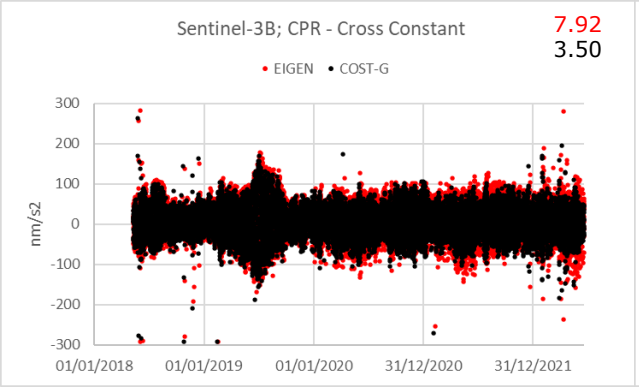
RESULTS

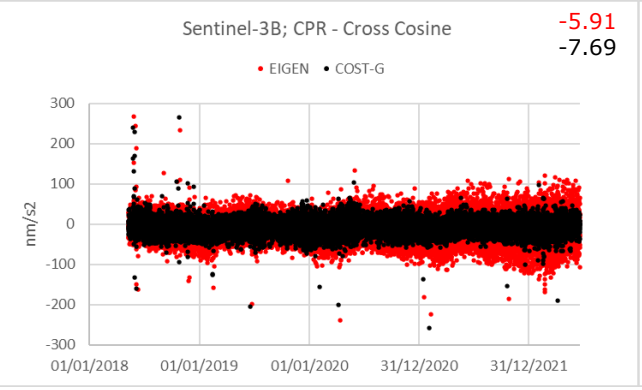
SENTINEL-3B CONSTANT PER REVOLUTION

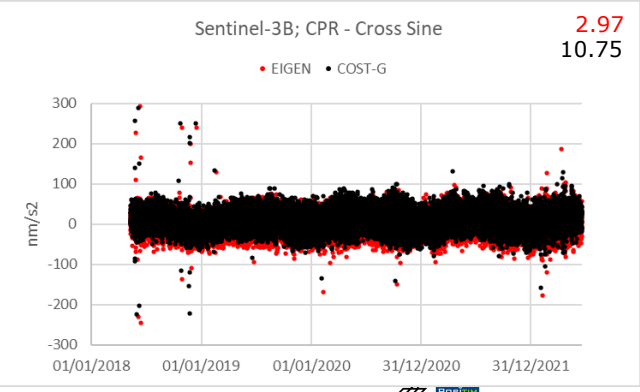






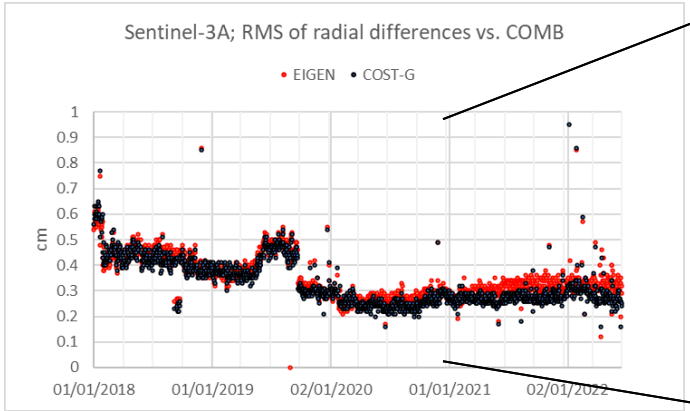


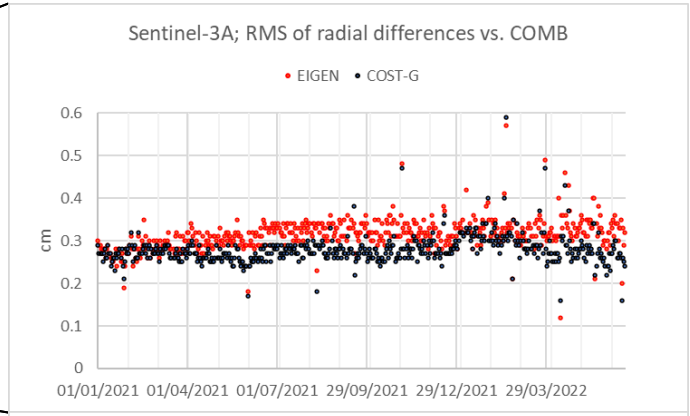


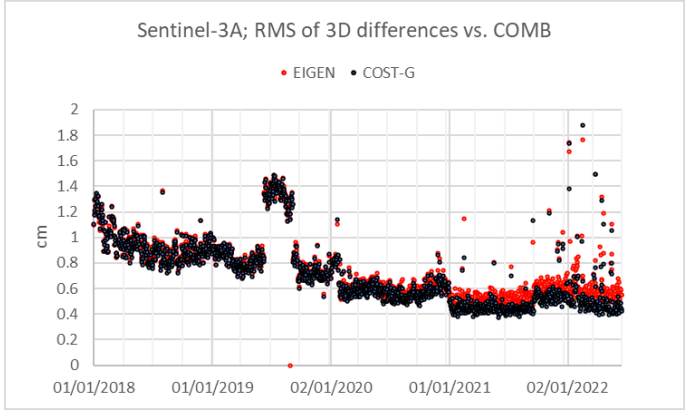


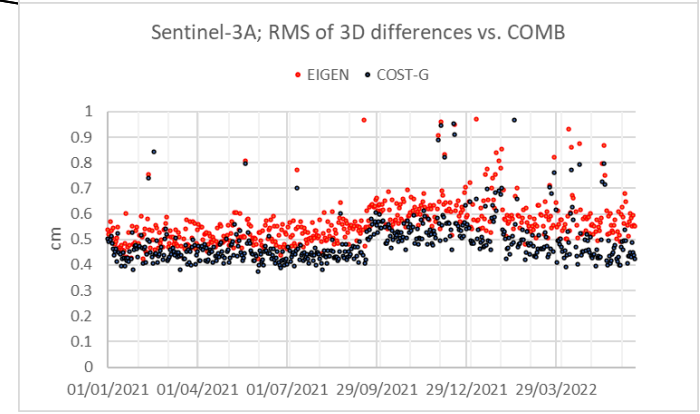
RESULTS

SENTINEL-3A DIFFERENCES VS. COMB



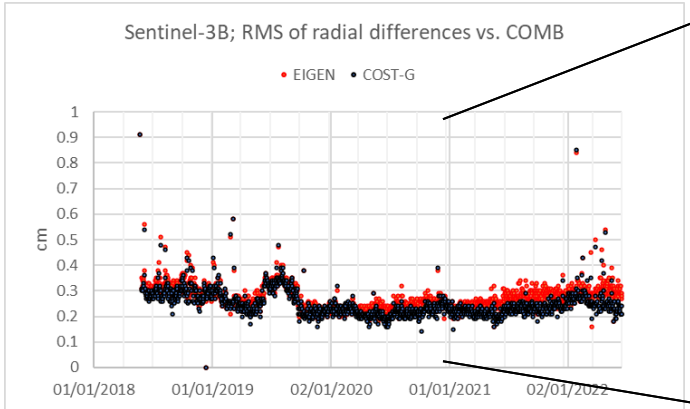


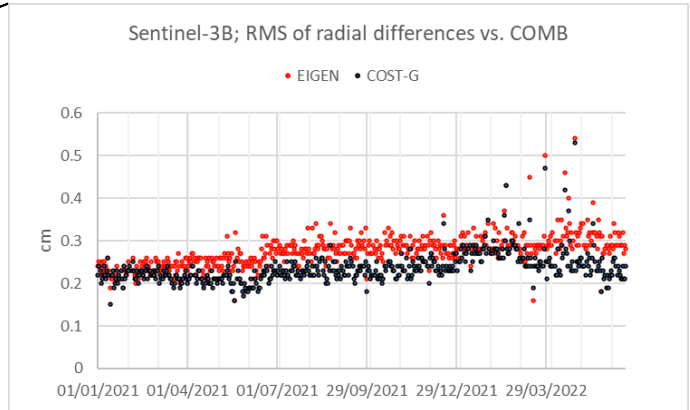


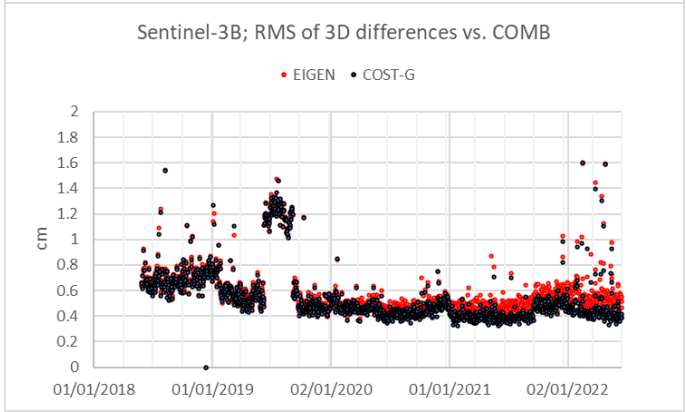


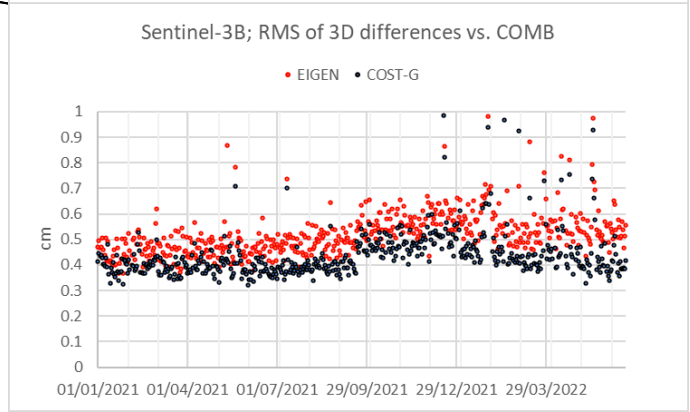
RESULTS

SENTINEL-3B DIFFERENCES VS. COMB



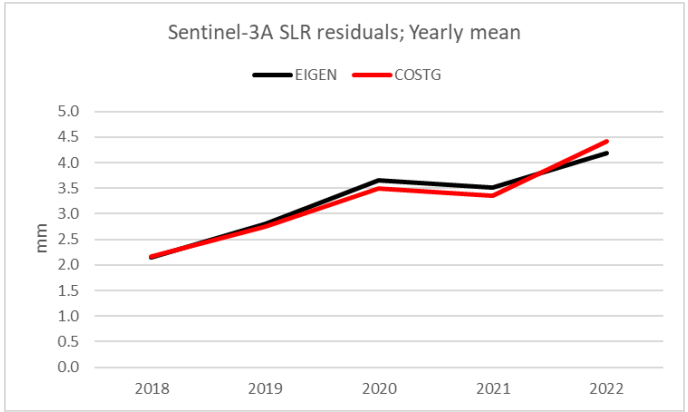


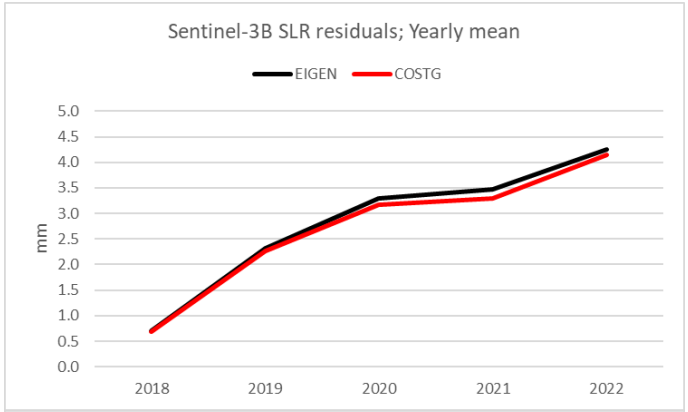


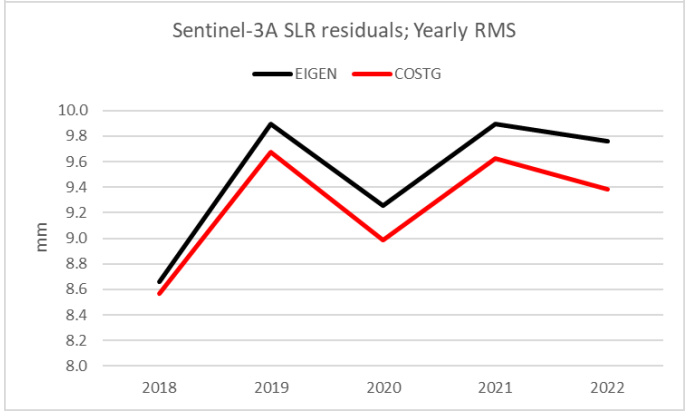


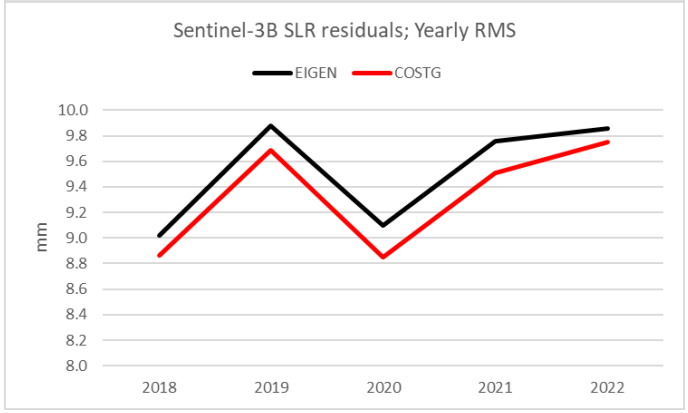
RESULTS

SENTINEL-3 SLR RESIDUALS – WITHOUT REMOVING STATION BIASES









CONCLUSIONS and NEXT STEPS

CONCLUSIONS AND NEXT STEPS

- The use of COST-G showed:
  - An increasing improvement on the accuracy (measured as differences vs. COMB) from 2020 onwards.
  - A reduction in the dispersion of CPR empiricals.

- Next steps are:

1. To complete the offline reprocessing:
   - Compute missing days
   - Refine SLR analysis removing station biases

2. To extend the reprocessing before 2018
   - Subject to the generation of an extended COST-G (on-going activity)

3. To compile a memorandum to distribute within the CPOD QWG to justify the use of COST-G in CPOD.

Thank you

Copernicus POD Service

Jaime Fernández (GMV)
Heike Peter (POSITIM)
Ulrich Meyer (AIUB)
Pierre Féménias (ESA/ESRIN)
Carolina Nogueira Loddo (EUMETSAT)