EVALUATION OF CNES RL05 BY AI AND PROSPECTS FOR A SIXTH RE-ITERATION

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SUMMARY

STATUS OF THE CURRENT CNES/GRGS RL05 RELEASE

- CNES/GRGS current time series, RL05, is available from April 2002 to May 2024
- Monthly and 10-day solutions up to degree 90
- Nominal inversion process is “Truncated SVD”
- But we also provide the monthly unconstrained solutions
- It is based on GRACE/GRACE-FO + geodetic SLR data (6 satellites)

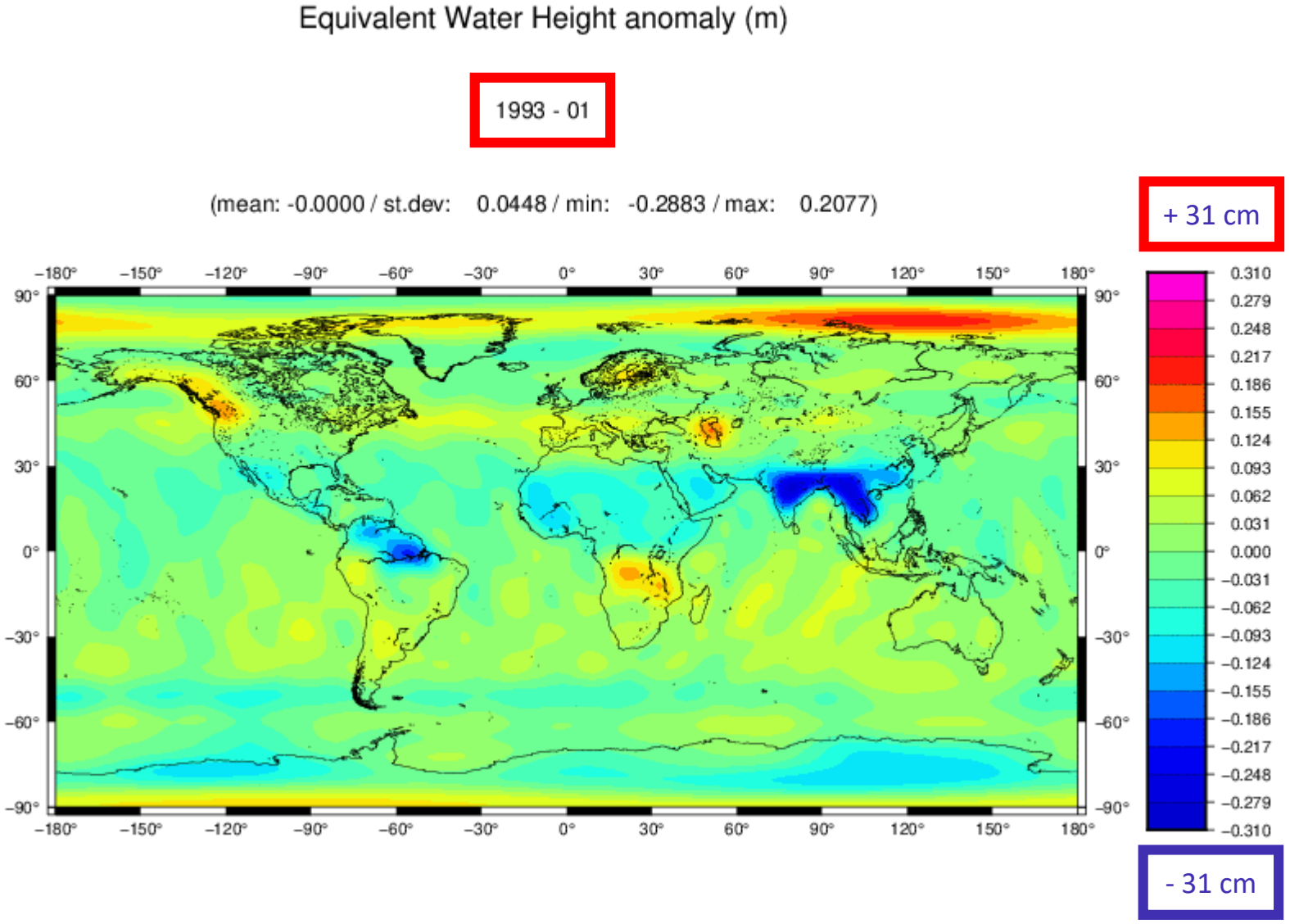
- Data weighting:
  - GPS ranges = 1 m
  - GPS undifferences phases = 2 cm
  - KBRR = 0.1 micrometer/s
  - SLR data (SLR satellites only) = 1 cm

- Parameterization:
  - KBRR bias + drift every half revolution
  - ACC bias + drift every half revolution
  - 1 ACC scale per day in X, Y, Z

STATUS OF RL05 MEAN FIELD FOR POD

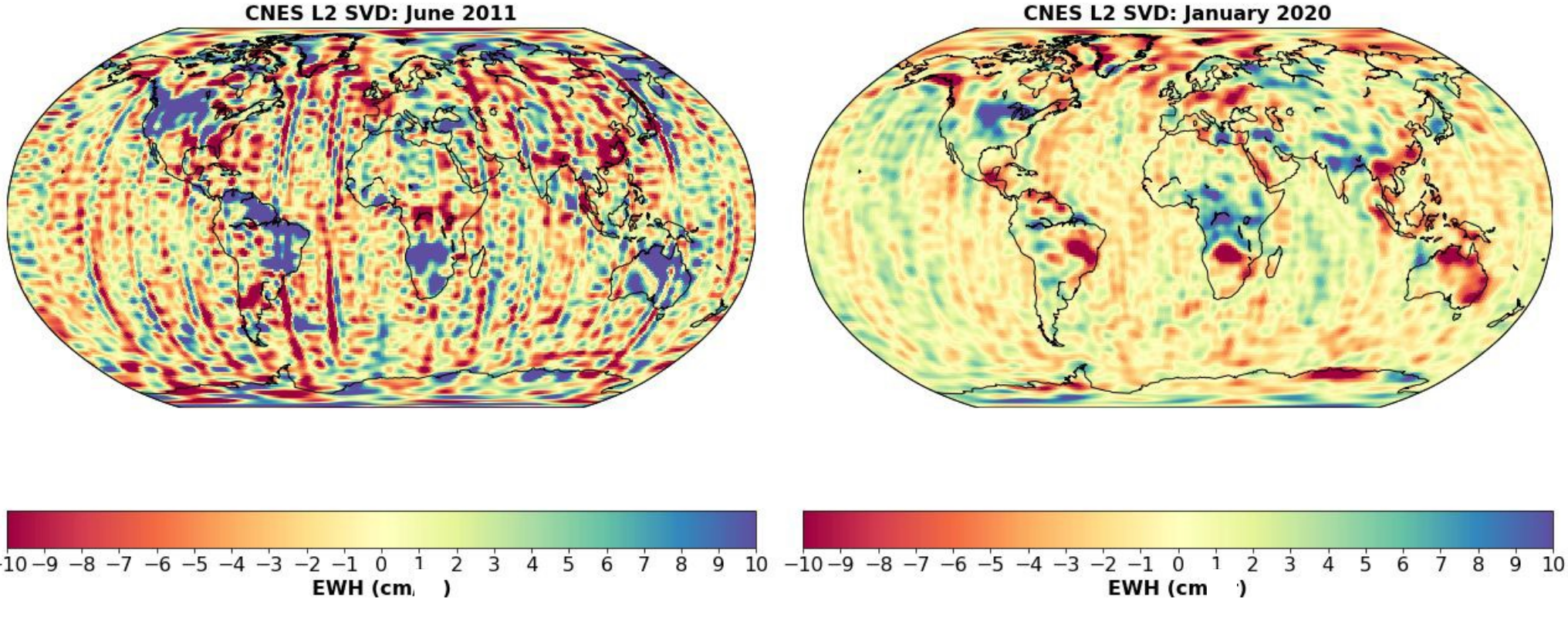
- Current Mean Field is “CNES_GRGS.RL05MF_combined_GRACE_SLR_DORIS”
- It is based on
  - SLR + DORIS data from 1993 to 2002 (“super-mascons”)
  - GRACE/GRACE-FO + SLR data from 2002 to October 2022
  - on extrapolation after October 2022
- It contains a solution for degree 1, which becomes obsolete with ITRF2020
- It will soon be updated with fresher GRACE-FO data → “CNES_GRGS.RL05MF_u202405”
- **Good performances in POD of altimetric satellites** (cf. Sergei Rudenko’s presentation at the OSTST 2024 POD session)
- Movie of the SLR + DORIS Time Variable Gravity solution before 2002…

MOVIE OF THE SLR + DORIS TVG SOLUTION 1993 - 2002



ASSESSMENT OF MONTHLY TVG SOLUTION QUALITY WITH AI

- Quality of the TVG solutions: usual metrics = RMS over the ocean, or over “quiet areas”
- We wanted to have a more in-depth view of error content of our solutions
- We asked the company Magellium to develop an analysis software of the TVG solutions by Artificial Intelligence

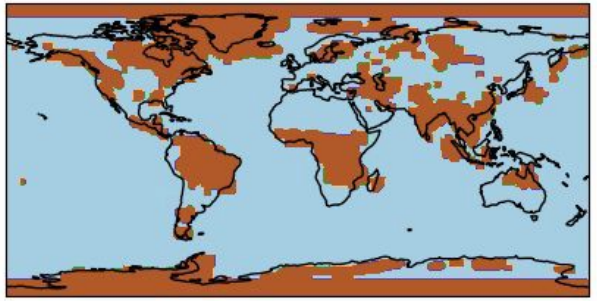


ASSESSMENT OF MONTHLY TVG SOLUTION QUALITY WITH AI

PROCESS

1- Create a mask

Exclude the zones where the hydrological signal is too strong



2- Choose a learning area

(red mask)

3- Hand labeling of "candidate" noise pixels

20 years (2002-2022)
240 TVG solutions
Exclude 5 months for validation purposes

4- Train the Machine Learning algorithms over the learning area

2 algorithms have been tested:

- Random Forest (RF)
- Convolutional Neural Network (CNN)

5- Once trained, generalize the detection of the noise pixels to the full globe

6- Compare the performance of the algorithms

Over the 5 months that have been entirely hand-labelled

7- Use the chosen algorithm to produce a new metric of the solutions quality

And apply it to the 20 years of data

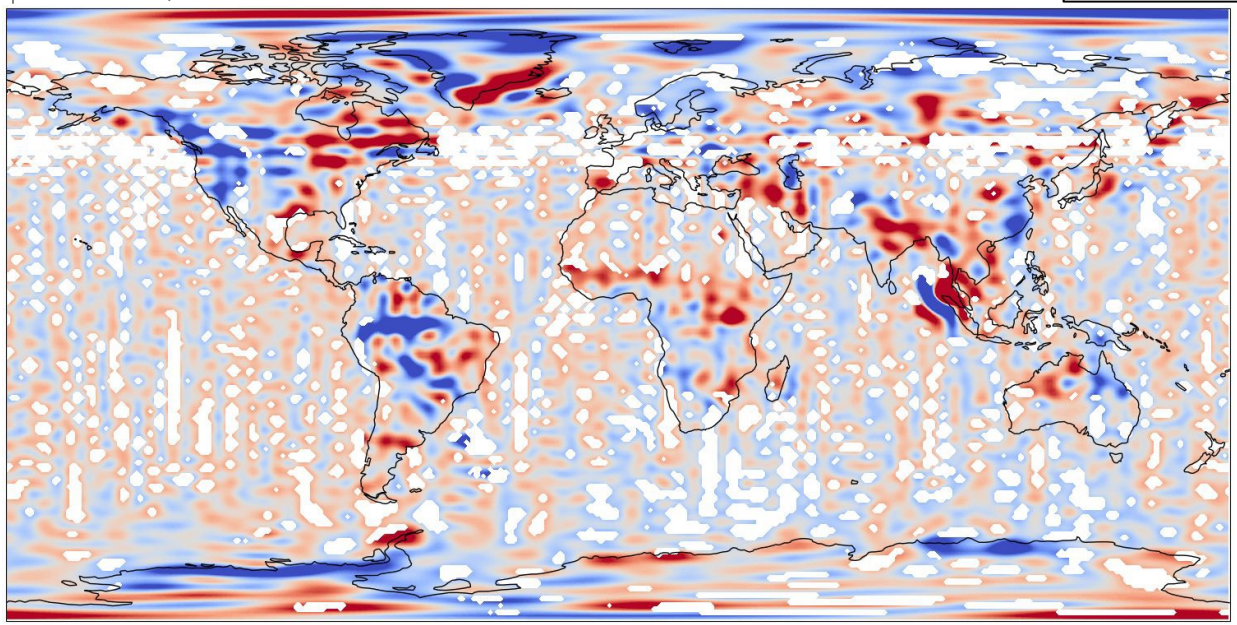
ASSESSMENT OF MONTHLY TVG SOLUTION QUALITY WITH AI

- The outcome of the Machine Learning process is, for each pixel, a **probability** that it is noise rather than signal

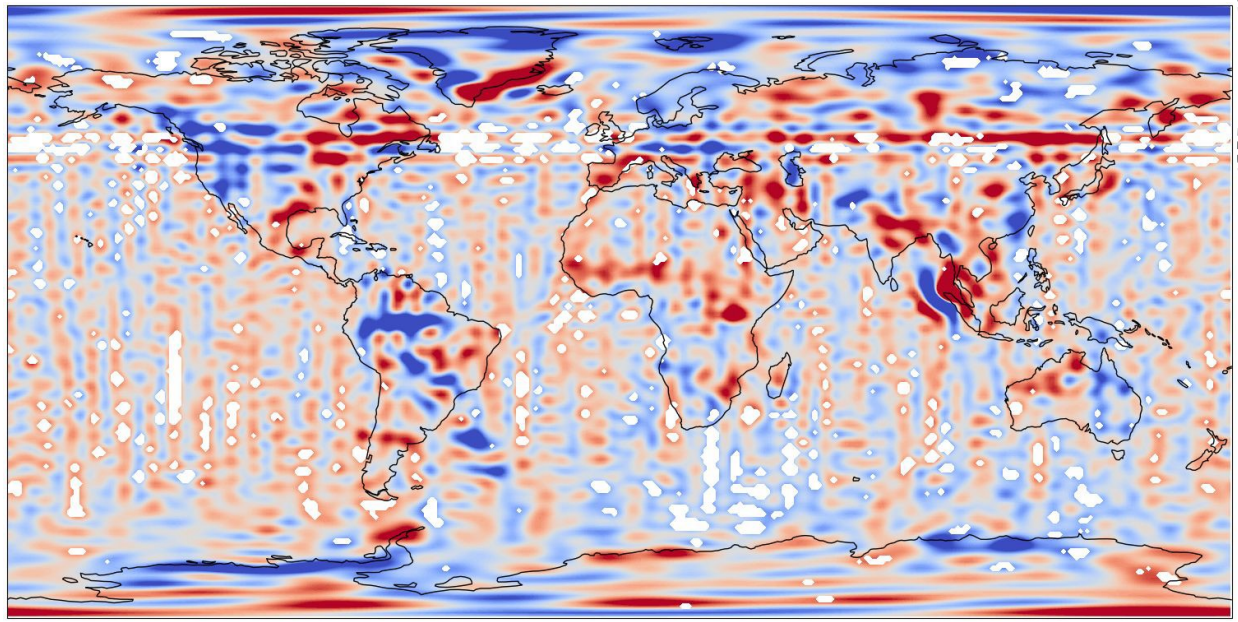
Date: 2004-05

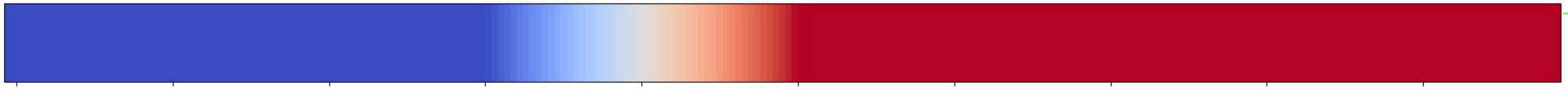
Detected noise pixels appear in white

RF algorithm
Minimal probability = 0.2



RF algorithm
Minimal probability = 0.8





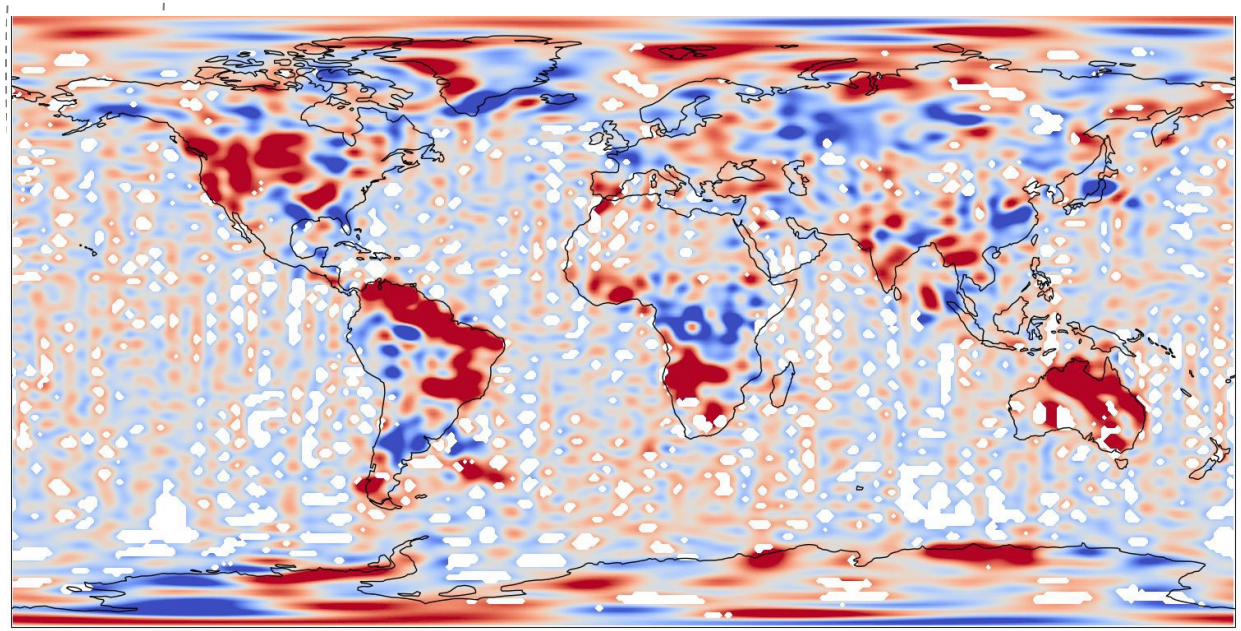
ASSESSMENT OF MONTHLY TVG SOLUTION QUALITY WITH AI

- For the same minimal probability, the 2 algorithms (RF and CNN) give different results

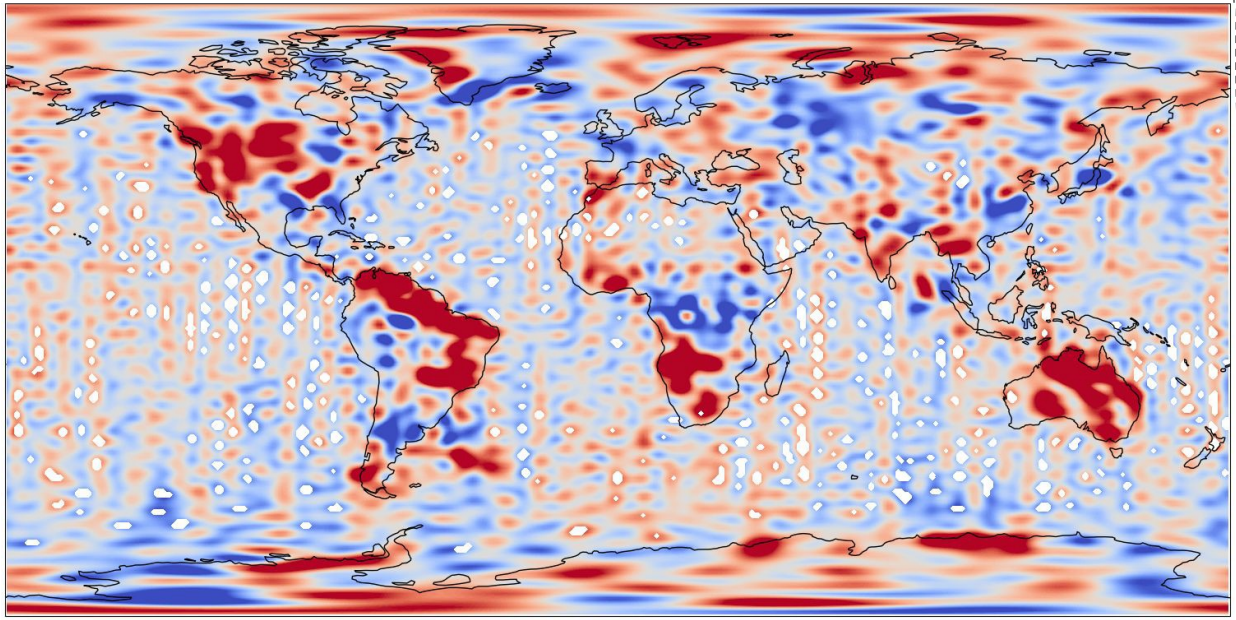
Date: 2011-05

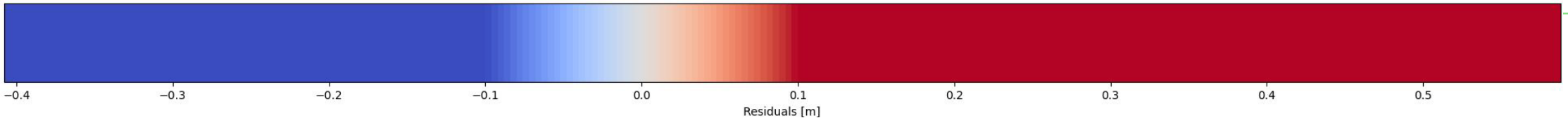
Detected noise pixels appear in white

RF algorithm
Minimal probability = 0.5



CNN algorithm
Minimal probability = 0.5





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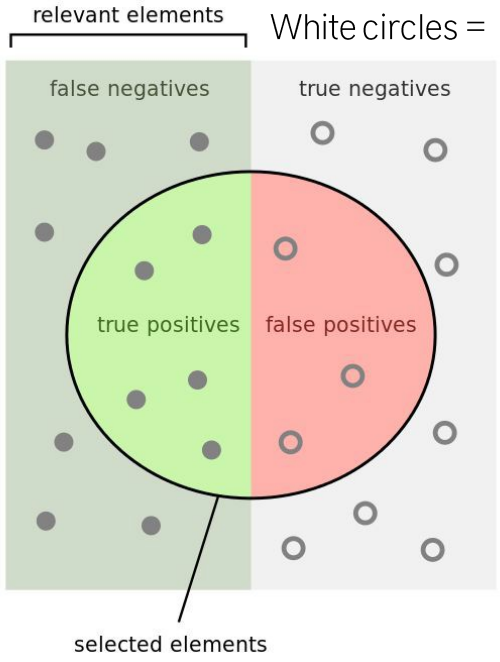
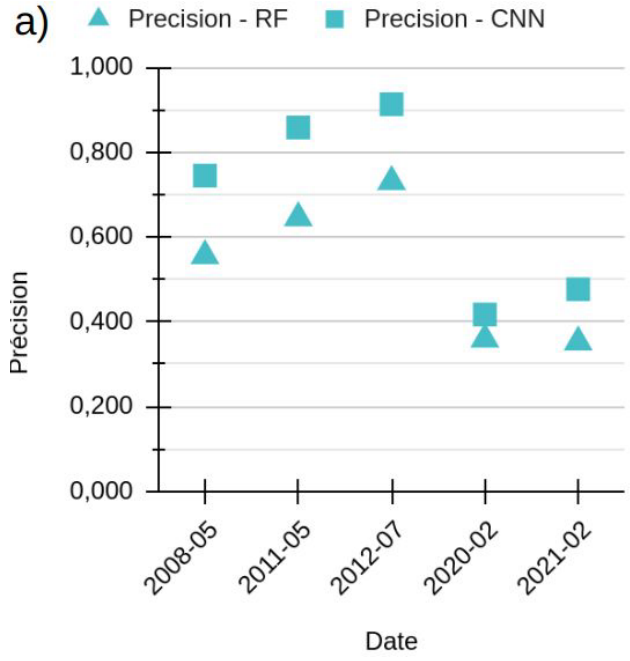
ASSESSMENT OF MONTHLY TVG SOLUTION QUALITY WITH AI

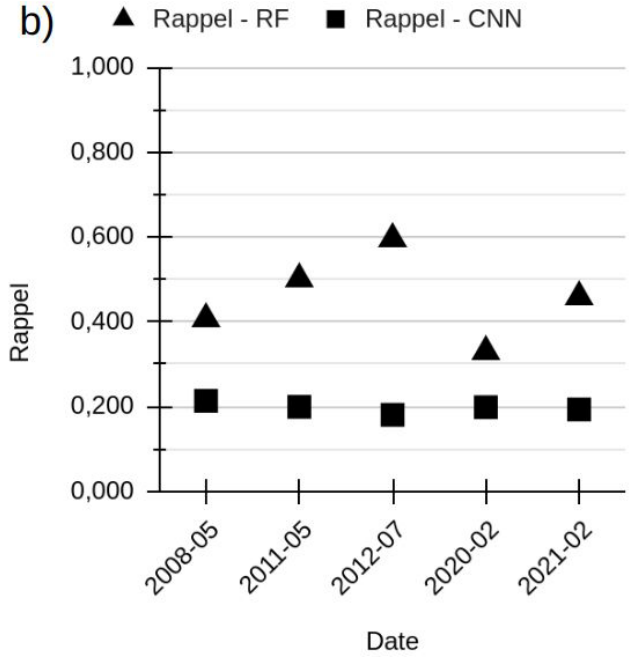
Performance of the 2 algorithms (RF & CNN)

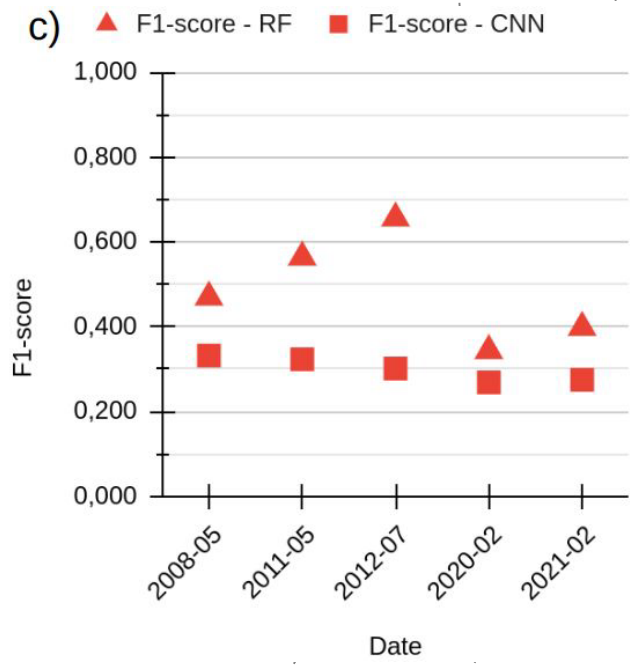
Black dots = noise pixels
White circles = signal pixels



- **Precision = Are the pixels I have detected as noise really noise ?**
- **Recall = Have I detected all the noise pixels there are?**
- The comparison is done here for a minimal probability = 0.5







How many selected items are relevant?

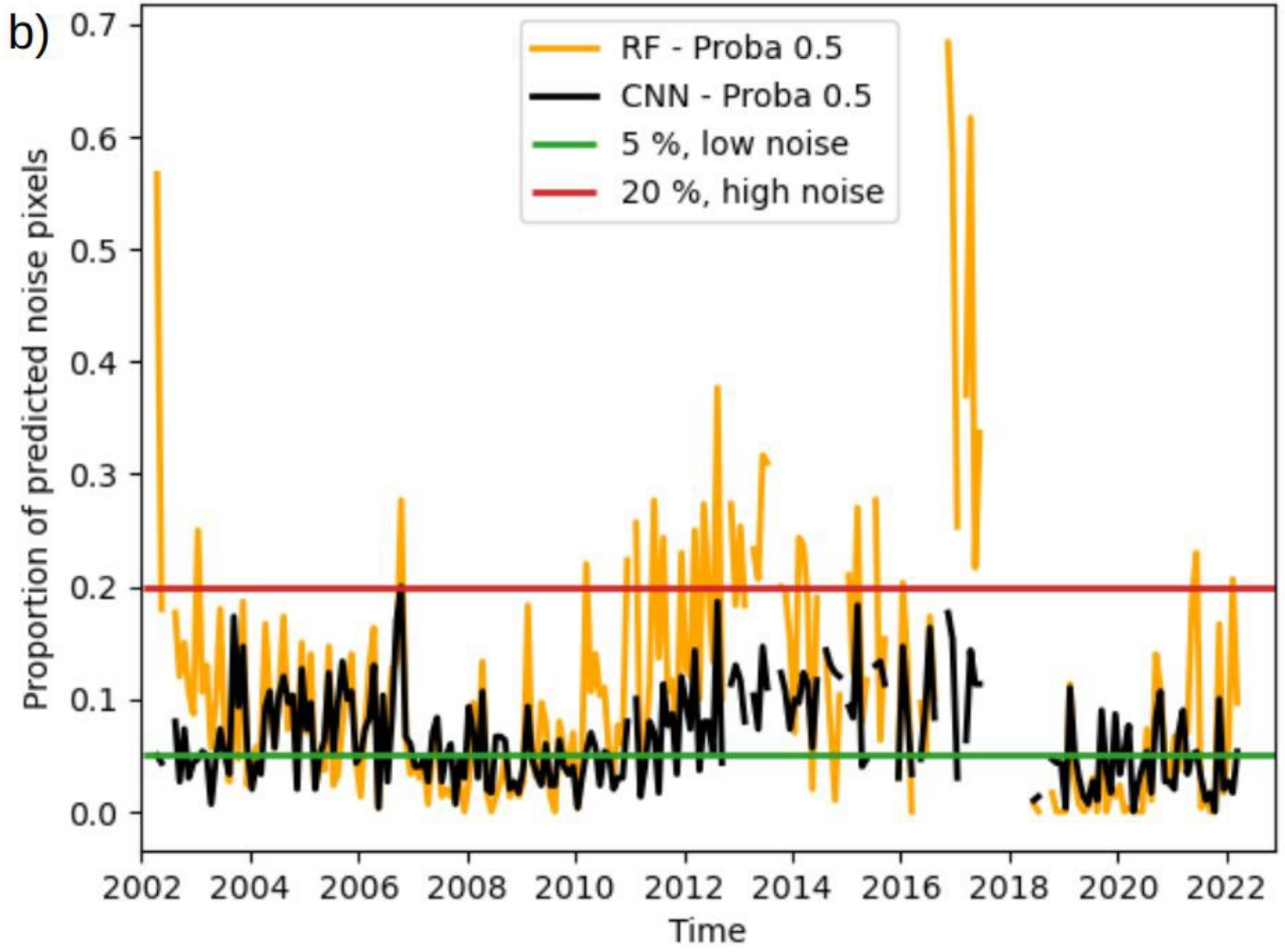
Precision = $\frac{\text{true positives}}{\text{true positives} + \text{false positives}}$

How many relevant items are selected?

Recall = $\frac{\text{true positives}}{\text{true positives} + \text{false negatives}}$

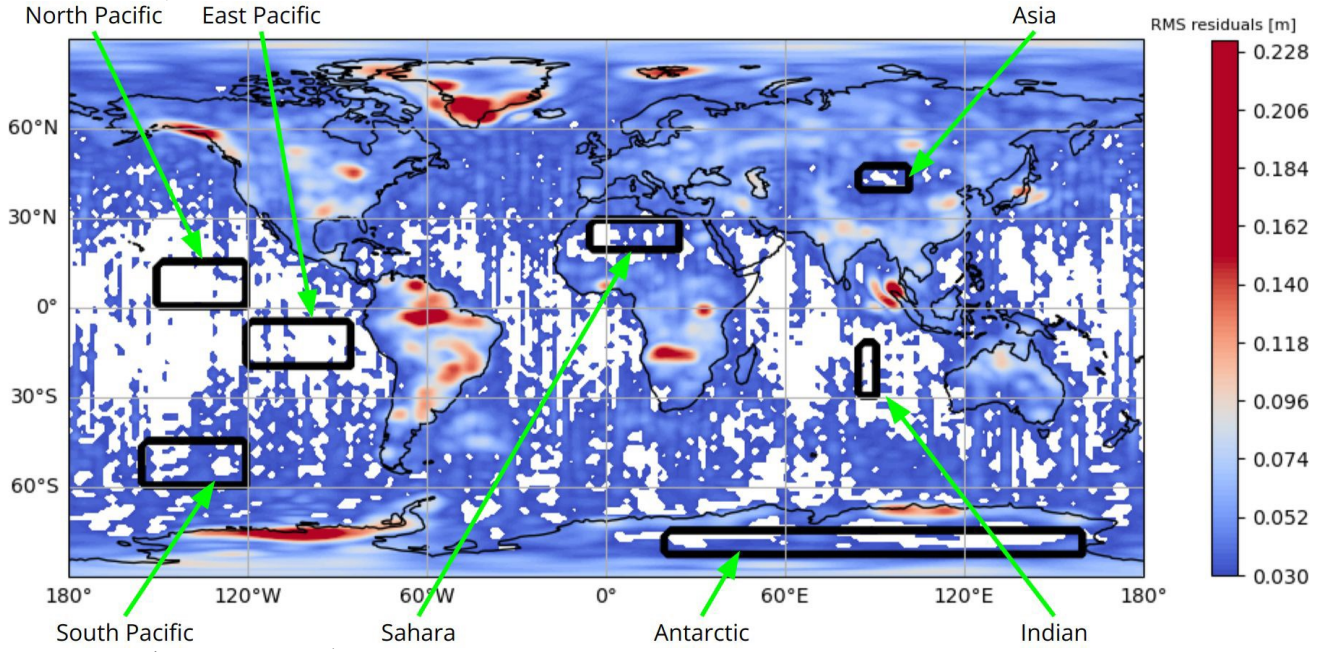
ASSESSMENT OF MONTHLY TVG SOLUTION QUALITY WITH AI

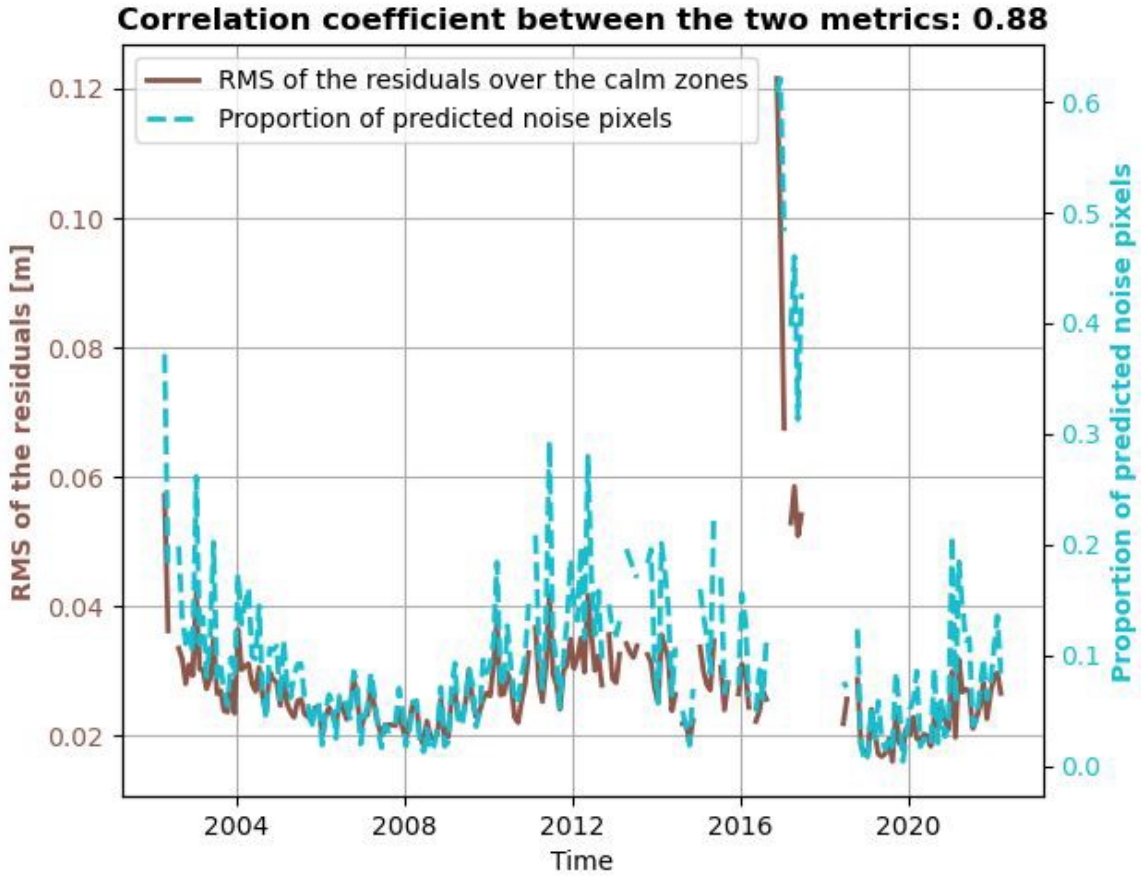
Results for 20 years of CNES/GRGS RL05 solutions



ASSESSMENT OF MONTHLY TVG SOLUTION QUALITY WITH AI

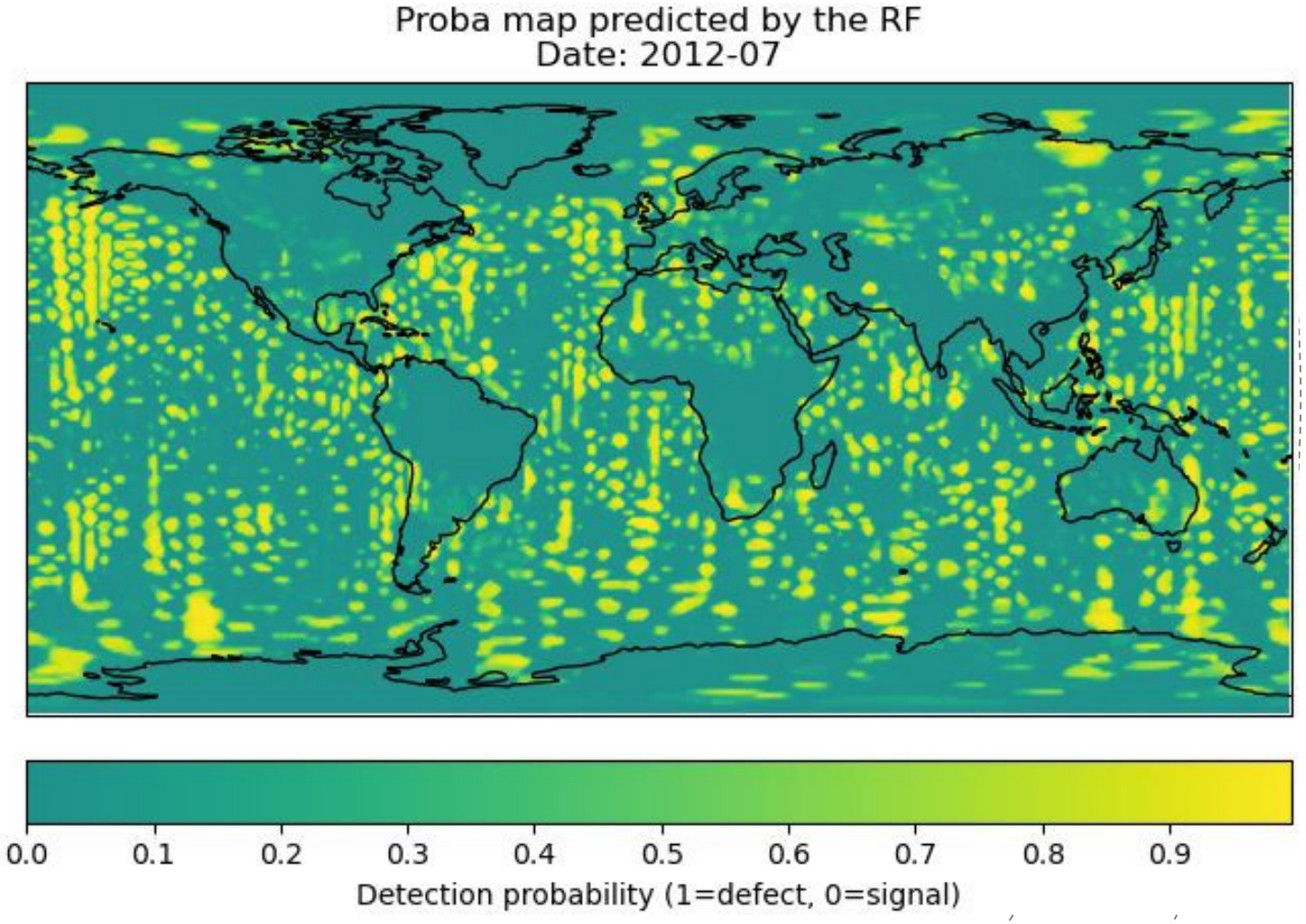
Comparison with the « RMS » metric over calm zones





ASSESSMENT OF MONTHLY TVG SOLUTION QUALITY WITH AI

AI analysis is not a simple statistic, but provides a probability map that each pixel is an error, which then allows adaptive filtering



PROSPECTS FOR A 6TH REITERATION

- Availability of the new FES2022 model and the corresponding TUGO ocean dealiasing model from the LEGOS/CLS team
- Introduction in our computations of the variances-covariance matrices of both the instruments (KBR, ACC) and the dealiasing models
- Processing the GPS measurements in fixed ambiguity mode
- Completely redefining the parameterization of the ACC and KBR measurements:

  ➔ Improved determination of C20 with GRACE-only

  ➔ See poster P13 (GSTM2024-88) by Maya Nocet-Binois

BACKUP SLIDES

RMS STATISTICS FOR CNES / JPL / TUGRAZ