Impact of the low elevation measurements on the DORIS scale factor and on the station position estimation

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2016 AGU Abstract ID: 147857

CLS COLLECTE LOCALISATION SATELLITES — cnes CENTRE NATIONAL D'ÉTUDES SPATIALES — GRGS GROUPE DE RECHERCHE DE GEODESIE SPATIALE

Introduction

All the DORIS Analysis Centers observe a jump in the scale factor of their combined solution in 2012. The introduction of the HY-2A satellite data in the solution seems to cause the largest jump in the DORIS scale. However, some investigations show that the Jason-2 and Cryosat-2 solutions are also responsible of the DORIS scale jump. This contribution in the scale jump seems fully explained by a variation in the number of low elevation measurements included in the processing. We propose here to demonstrate the origin of this scale jump by several tests in particular by taking into account another data format (RINEX) and by processing DORIS data with different cutoff angles. We also analyze the impact of the low elevation measurements on the height station position estimation and the Helmert parameters (scale factor and geocenter)..

Processing context

We analyzed DORIS data on 3.5-day arcs and with a cut-off angle of 12°, computed with GINS/DYNAMO software

- **Configuration:** we use the same configuration as that used for the ITRF2014 contribution
- **Time span of the processing:** January 2011 to June 2015
- **DORIS data:** DORIS2.2 and RINEX 3.0 phase measurement converted to DOPPLER
  Satellites: Jason-2, Cryosat-2 and HY-2A

Single satellite and multi-satellite solutions compared to DPOD2008

We computed weekly single satellite solutions for Jason-2, Cryosat-2, HY-2A from January 2011 to June 2015. Comparisons of these weekly solutions to DPOD2008 are performed with the CATREF (Combination and Analysis of Terrestrial Reference Frames) package.

Impact of the cutoff angle on the DORIS scale and on the station position estimation

The processing of the DORIS data from January 2011 to June 2015 for Jason-2 and Cryosat-2 was performed by considering two cut-off angles (10 ° and 20 °).

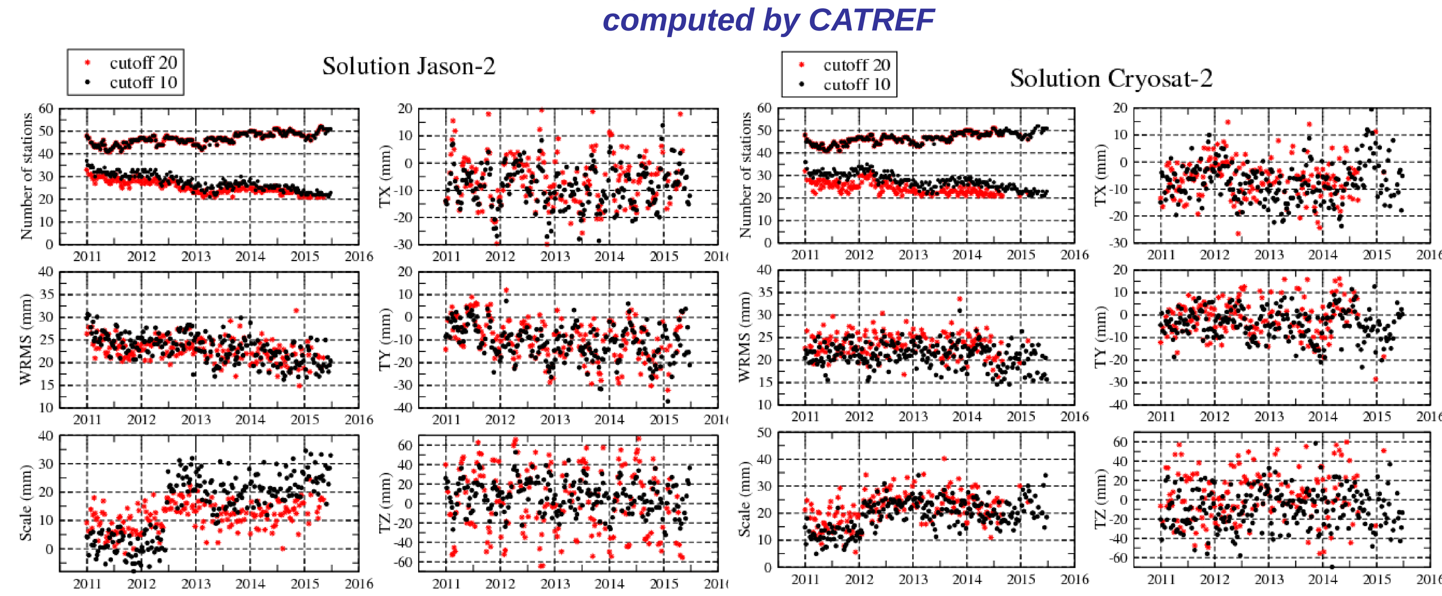
Impact of the cutoff angle on the DORIS scale factor

We are interested in the impact on the scale factor. We determined the single-satellite Jason-2 and Cryosat-2 weekly solutions that we compared to DPOD2008 with CATREF.

These results show that measurements at low elevations have a significant impact on the scale factor. It can be seen that the scale factor is at a different level depending on the cut-off angle used.

In addition, as discussed in more detail in an other section, a jump in the scale factor was observed in 2012. These figures show that with a 20° cut-off angle, the scale factor jump in 2012 is significantly reduced. The number of higher measurements at low elevations could be the cause of the scale factor jump observed in 2012.

Jason-2 and Cryosat-2 single satellite Solution compared to DPOD2008 computed by CATREF



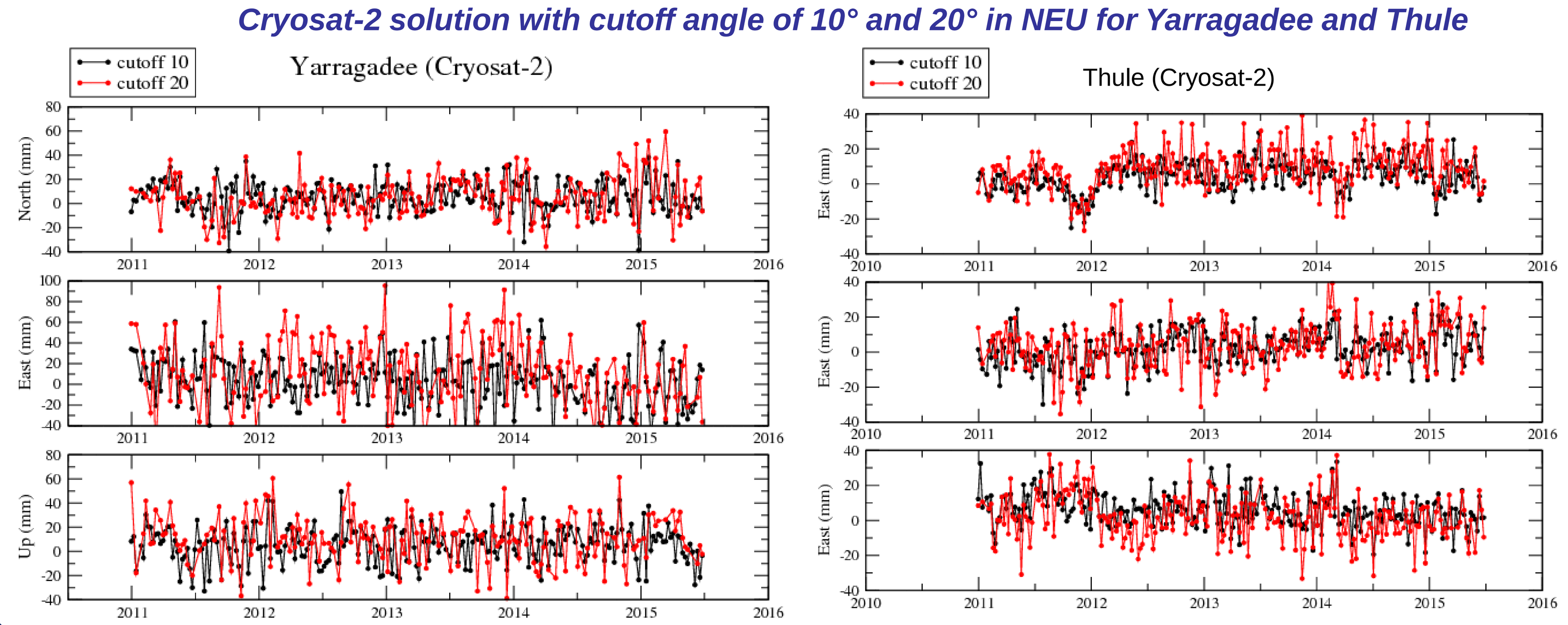
With an elevation cutoff angle of 20° the scale change in 2012 is significantly reduced

The larger number of data, especially at low elevation, is the cause of the change we observe in the scale factor for Jason-2 single-satellite solutions with the doris2.2 dataset

Impact of the cutoff angle on the station position estimation

We are now interested in the impact of the cutoff angle on the DORIS station position estimation. We analyzed the time series of the differences to DPOD2008 of the Jason-2 and Cryosat-2 single-satellite solutions for all DORIS stations observed over the time span processed. We did some comparisons for different stations with the POD CNES team. These comparisons allowed to identify the cause of the scale factor jump in 2012 (explained in the dedicated section). The results of the Cryosat-2 single-satellite solution for two stations, Yarragadee and Thule show that the cutoff angle has no significant impact on the station position estimation. The 10° cut-off allows a more stable determination thanks to a larger number of measurements. Let us now focus on the Jason-2 single-satellite solution. As the Cryosat-2 USO is not affected by the South Atlantic Anomaly (SAA), we use the Cryosat-2 single-satellite solution as a reference. The table presents the differences between the Jason-2 and Cryosat-2 solutions in North/East/Up for the different stations in the SAA region and one outside (Yarragadee), for two different cut-off angles: 10° and 20°. The differences between the Jason-2 and Cryosat-2 solutions are noticeably smaller with a cut-off angle of 20°, but only for SAA stations. These comparisons show the sensitivity of Jason-2 to the SAA effect.

Cryosat-2 solution with cutoff angle of 10° and 20° in NEU for Yarragadee and Thule



Differences between the Jason-2 and Cryosat-2 solutions in NEU

Mean of weeks from Jan. 2011 to Jun. 2015

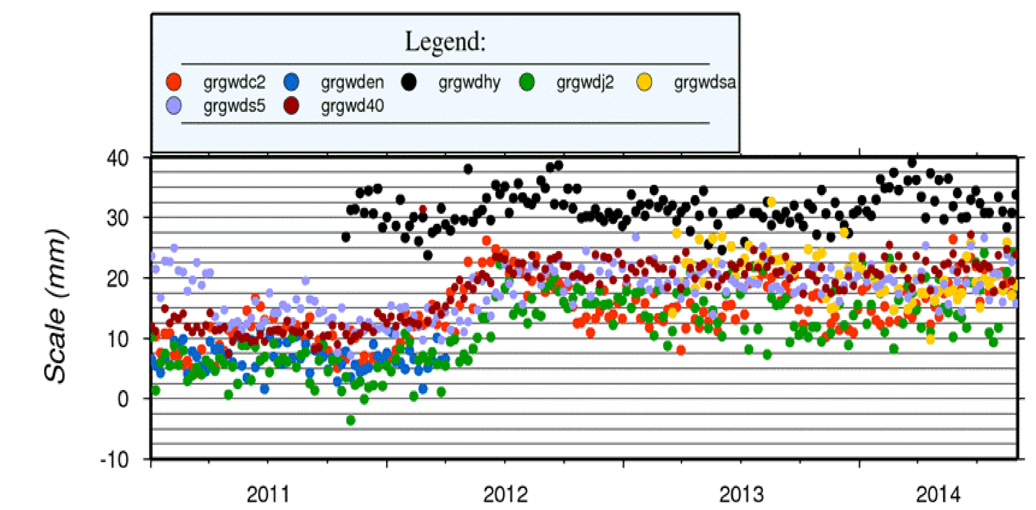
Station	Jason-2 10° (in cm) North	East	Up	Jason-2 20°(in cm) North	East	Up
Cachoeira	4.5	3.2	9.6	2.6	5.4	5.5
Arequipa	-2.5	2.9	9.4	-2.6	1.7	2.9
Kourou	-3.2	0.2	2.8	-1.4	0.8	1.6
Ascension	0.5	-3.8	6.2	0.9	-3.6	4.5
Saint Helene	5.6	-0.6	3.4	4.1	-1.1	1.9
Tristan	-1.1	2.1	-2.5	-1.4	0.6	-1.6
Santiago	8.5	0.1	1.4	6.2	0.1	0.9
Libreville	-5.1	-1.2	5.0	-1.9	-1.3	1.9
Yarragadee	0.5	1.6	0.5	0.1	1.9	1.4

DORIS scale jump in 2012

Scale jump in 2012 in the IDS combined solution provided for the ITRF2014 realization

An increase in the scale factor was observed in 2012 in the IDS combined solution. This increase is mainly due to the introduction of the HY-2A satellite, which has a high scale factor. However, some investigations have shown that part of the increase is also due to the Jason-2 and Cryosat-2 satellites, which have a scale jump in 2012.

GRG scale from single satellite and multi-satellite solutions compared to ITRF2008



GRG Scale factor for Jason-2, Cryosat-2, HY-2A and the multi-satellite solutions from doris2.2 data and RINEX data

First, we investigate if we still observe a jump in the scale factor when we use DORIS data in RINEX format instead of Doris2.2. We processed the Doris2.2 and RINEX data for the Jason-2, Cryosat-2 and HY-2A satellites. The single-satellite solutions and a multi-satellite solution (combination of the 3 satellites) were also determined by considering the two types of data format. These solutions were compared to DPOD2008 and the resulting scale factors for each solution are shown.

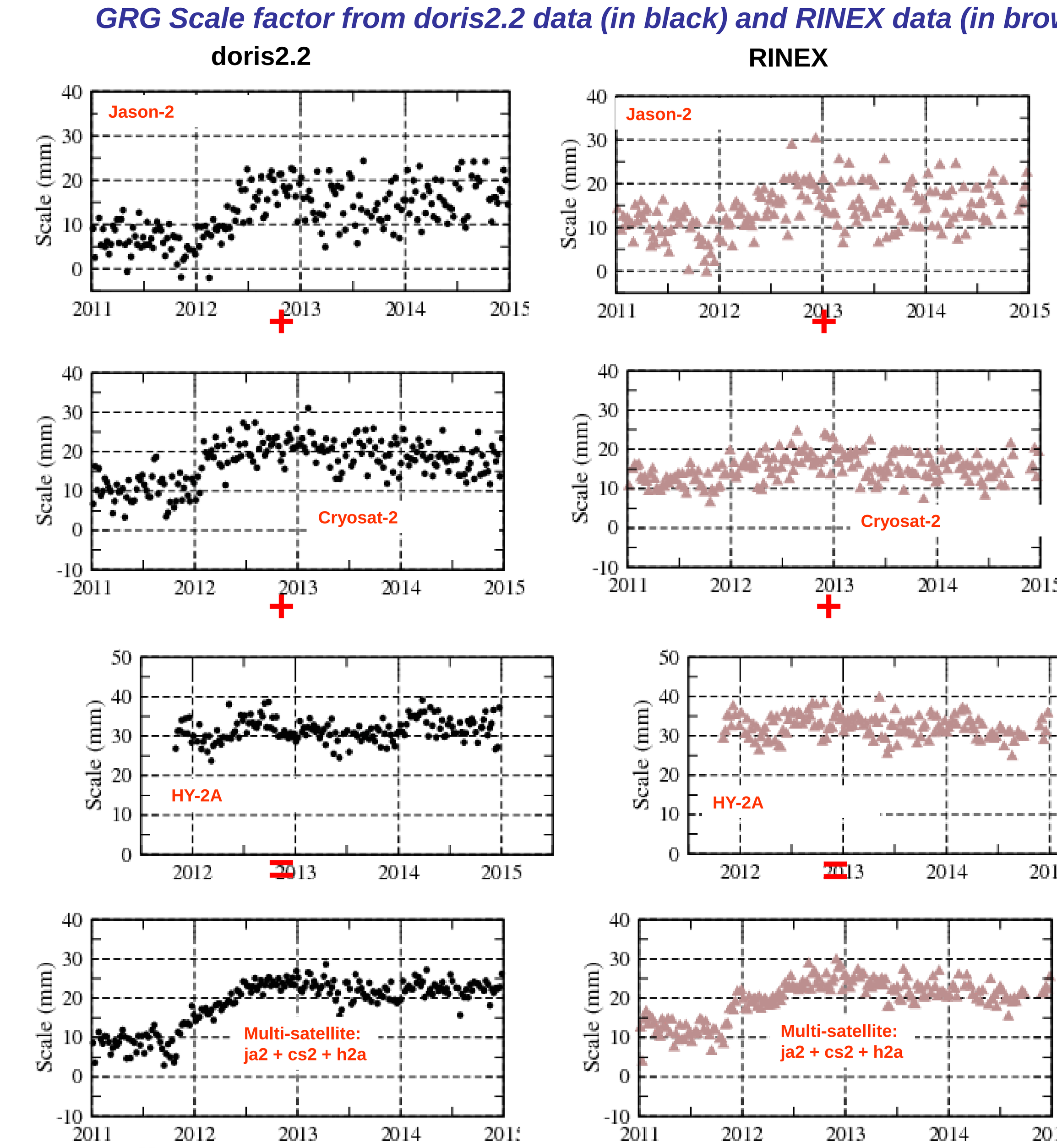
Doris2.2 data case:

In the case of Doris2.2 data, there is no scale change for HY-2A, but the value of the scale is much higher than for the other satellites. For Jason-2 and Cryosat-2 there is a scale increases in 2012, at two slightly different moments: early 2012 for Cryosat-2, mid-2012 for Jason-2, coincident with changes in the standards used in the Doris2.2 measurements production. The jump in scale for the multi-satellite solution is due to the combination of the scale jumps of Jason-2 and Cryosat-2, and the introduction of HY-2A with its high scale value.

RINEX data case:

In the case of RINEX data, there is no jump of the scale factor for Jason-2 and Cryosat-2, but the scale of HY-2A remains high. The scale jump for the multi-satellite solution is only due to the high scale factor of HY-2A.

GRG Scale factor from doris2.2 data (in black) and RINEX data (in brown)



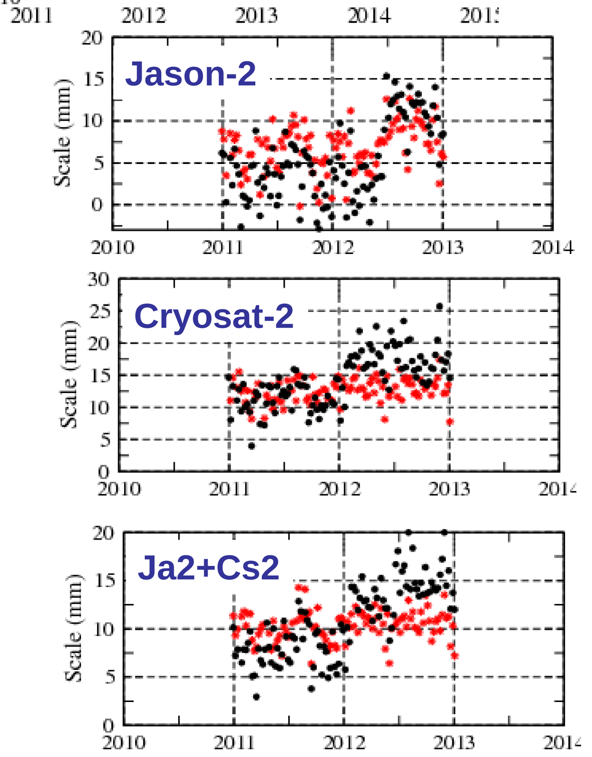
Explanation of the scale factor increase:

CNES POD team produces the DORIS data files in the Doris2.2 format using their POD processing to flag a number of measurements considered invalid in their pre-processing. In 2012 the transition from the GDR-C to the GDR-D standards in the POD processing included a change of tropospheric model (from the CNET model to the GPT/GMF model). The new tropospheric model, more accurate than the former one, allowed to validate more measurements at low elevations and thus reduced the number of measurements marked as rejected in the Doris2.2 measurement file. The increase of low-elevation measurements in the Doris2.2 data processed by the Analysis Centers explains the jump of scale factor in 2012 for Jason-2 and Cryosat-2, at the dates when the change of standards occurred.

GRG Scale factor for Jason-2, Cryosat-2 and the multi-satellite solutions from Doris2.2 data with CNES POD and GRG pre-processing

We evaluated Jason-2 and Cryosat-2 mono-satellite solutions obtained by considering all the measurements of the Doris2.2 data file, even those flagged (having been rejected by the pre-processing of the CNES POD team). When we apply the CNES POD pre-processing (in black), a jump of the scale factor for Jason-2 and Cryosat-2 is observed. When the flagged measurements are also taken into account (in red) in our processing, the jump of the scale factor disappears. Then, we conclude that the jump observed in the scale factor is due to the tropospheric model change in the POD processing of the CNES POD team.

It is therefore recommended that the Analysis Centers take into account all the measurements of the Doris2.2 file, even those rejected by the CNES POD team pre-processing and thus carry out their own pre-processing.



GRG Scale factor for Jason-2, Cryosat-2 and the multi-satellite solutions from Doris2.2 data with CNES POD (in black) and GRG pre-processing (in red)

Conclusions

DORIS scale jump in 2012:

The increase of the scale factor for Jason-2 and Cryosat-2 is fully explained by the change of tropospheric model used by CNES POD team in its POD processing (GDR standards): from CNET (GDR-C) to GPT/GMF (GRD-D). The larger number of data, especially at low elevation, is the cause of the change we observe in the scale factor.

Impact of the cutoff angle on the DORIS scale factor on the station position estimation:

With an elevation cutoff angle of 20° the scale change in 2012 is significantly reduced. Changing the cutoff angle and/or downweighting low measurements has an impact on the scale factor. In terms of station height, the cutoff angle has mostly an impact on the SAA stations for the Jason-2 single satellite solution.

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