GRG DORIS RINEX data processing

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DORIS RINEX data processing

1- Practical information on the processing of the RINEX measurements

- The data fields available in the RINEX files, how they relate to the measurement equation
- The geopotential values to be used in the relativistic corrections
- The ionosphere correction and the associated phase centers to use

2- Test processing of Doris2.2 and RINEX formats over 3.5 years on Jason-2

Line of the DORIS/RINEX file header (in red) describing the 10 DORIS observation fields:

```
G    5 C1P L1P L2C C2C S2C                                  SYS / # / OBS TYPES
R    2 C1C L1C                                              SYS / # / OBS TYPES
E    2 L1B L5I                                              SYS / # / OBS TYPES
S    2 C1C L1C                                              SYS / # / OBS TYPES
D   10  L1   L2   C1   C2   W1   W2   F    P    T    H      SYS / # / OBS TYPES
```

Example of a DORIS/RINEX epoch record:

```
> 2001 08 21 00 00 39.939956370  0  2        -1.084696938 0
```

Example of two DORIS/RINEX observation records:

```
D01 -1907631.062 1   -3759884.691 1  32743488.281 1  32743301.603 1      -130.250 7
       -116.250 7      2361.256         1000.820 1        0.000 1        72.732 1
D02      -0.000 1        -0.000 1  32884249.705 2  32884916.645 2      -139.000 7
       -126.400 7      2361.256         1000.773 1       16.628 1        72.738 1
```

$N_{DOP}=L1(t_{i+1})-L1(t_i)$

$\Delta\tau_r=(t_{i+1})-(t_i)$

Measurement equation:

$$\begin{cases} v_{measured} = \dfrac{c}{f_{e_N}}\left(f_{e_N} - f_{r_T} - \dfrac{N_{DOP}}{\Delta\tau_r}\right) + \Delta v_{IONO} + \Delta v_{REL_C} \\ v_{theo} = \dfrac{\rho_2 - \rho_1}{\Delta\tau_r} + \Delta v_{TROPO} - \dfrac{c\left(\dfrac{N_{DOP}}{\Delta\tau_r} + f_{rT}\right)}{f_{e_N}} \dfrac{\Delta f_e}{f_{e_N}} \end{cases}$$

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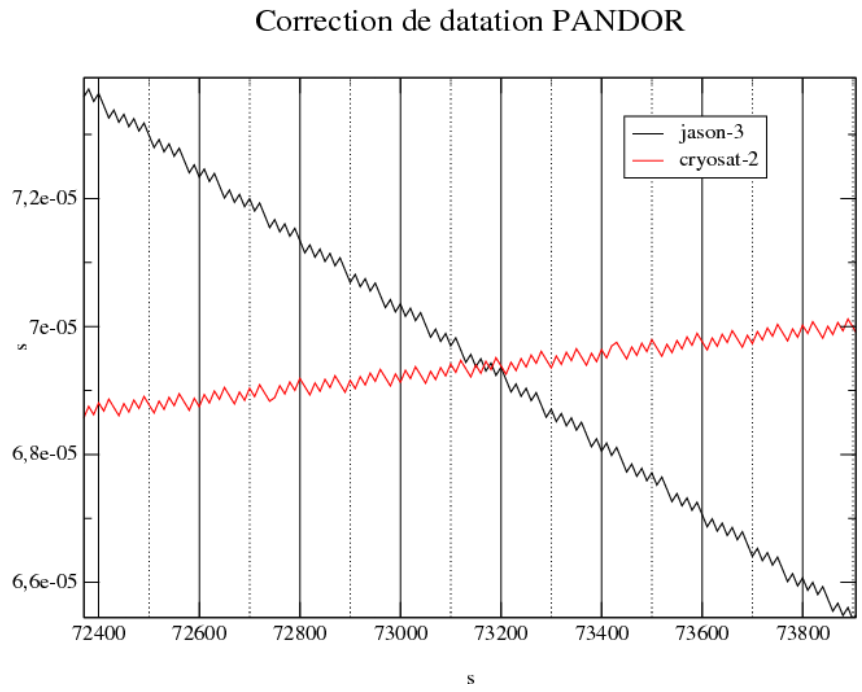
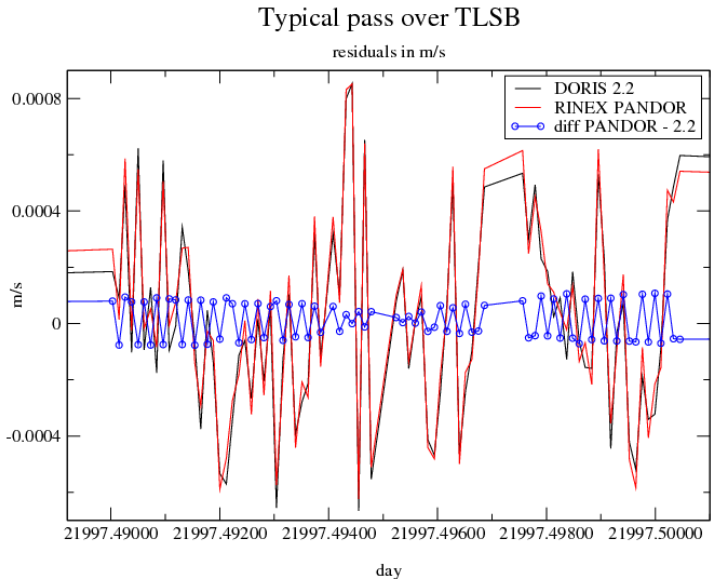
« RCO » field. Either comes:
- **from DIODE (« STILO » acronym in the header)**
- **or from PANDOR (« PANDOR » acronym in the header)**



PROBLEM: This field had short-term variations in the first version of PANDOR
- → **High frequency noise on the count duration**
- → **Additional noise in the Doppler residuals**
- → **Problem solved in the next version of PANDOR**



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S    2 C1C L1C                                                  SYS / # / OBS TYPES
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```

« F » field: $f_{r_T} = f_{r_N}\left(1+\Delta f_r / f_{r_N}\right)$

PROBLEM: This field comes from DIODE, it is not smooth (jumps when passing over time beacons)

→ **Something has to be done before using it: linear or polynomial regression based on one day or more of data**

Status on Jason-2 DORIS RINEX data

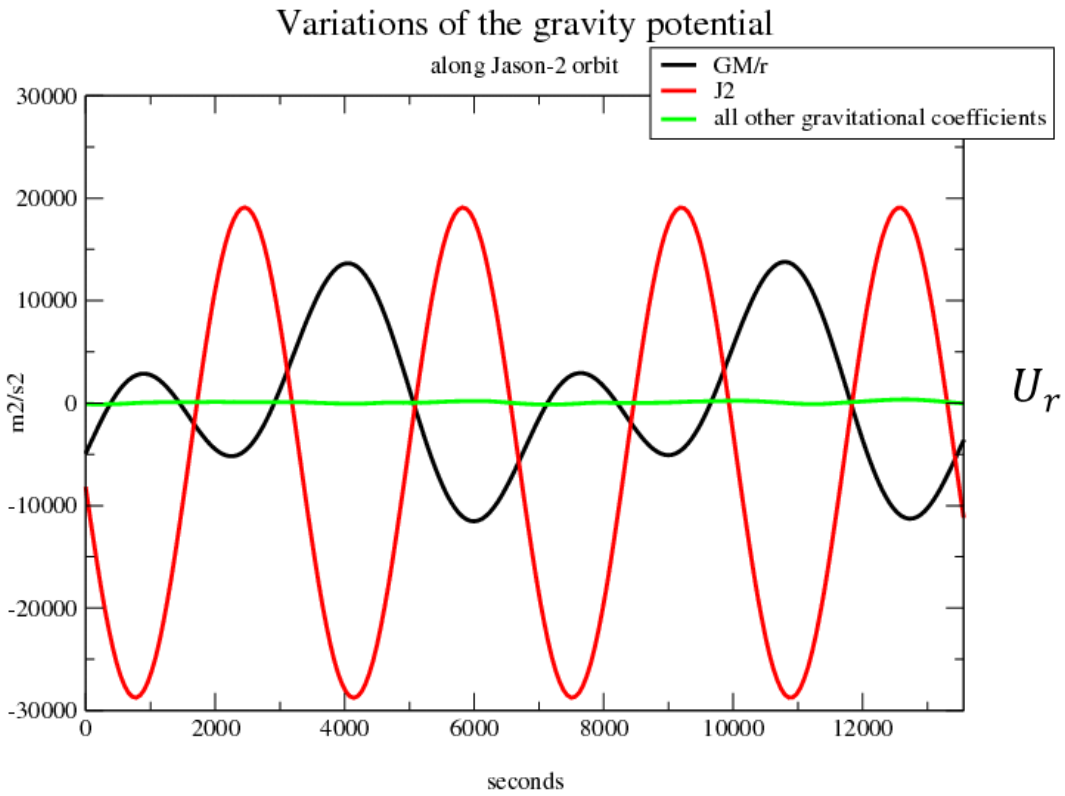
DORIS RINEX data downloaded at CDDIS since 2012

Time span (dd/mm/yyyy)	RINEX Origin	Download Date
19/06/2008-10/08/2011	STILO	In 2012
11/08/2011-06/02/2012	STILO_BN1_2.3	In 2012 And 2015 for 2012
07/02/2012-06/06/2012	STILO_BN1_3.0	In 2015
07/06/2012-17/11/2013	STILO_BN1_3.1	In 2015
18/11/2013-06/11/2014	STILO_BN1_3.1P3	In 2014-2015
07/11/2014-16/01/2015	STILO_BN1_4.3	In 2014-2015
17/01/2015-25/012015	PANDORBN1_4.3	In 2015
26/01/2015-02/06/2015	PANDOR1_4.4	In 2015
03/06/2015-26/11/2015	PANDOR1_4.4P1	In 2015

Geopotential

$$\Delta v_{REL_C} = \frac{1}{c}\left[U_r - U_e + \frac{V_r^2 - V_e^2}{2}\right]$$

The computation of U_r cannot be restricted to the central term only; J_2 brings an important contribution:



$$U_r = \frac{\mu}{r}\left(1 - \left(\frac{a_e}{r}\right)^2 J_2 \frac{3\sin^2(\varphi) - 1}{2}\right)$$

Ionospheric corrections

Iono-free phase combination:

$$L_{iono-free-2GHz} = \frac{\gamma L_{2GHz} - \sqrt{\gamma} L_{400MHz}}{\gamma - 1} = L_{2GHz} + \frac{L_{2GHz} - \sqrt{\gamma} L_{400MHz}}{\gamma - 1}$$

with $\gamma = \left(f_{2GHz} / f_{400MHz} \right)^2$

Iono-free phase center coordinates:

$$\vec{r}_{2GHz,iono-free} = \frac{\vec{r}_{400MHz,2GHz}}{\gamma - 1}$$

Where $\vec{r}_{2GHz,iono-free}$ is the vector from the 2 GHz phase center to the iono-free phase center and

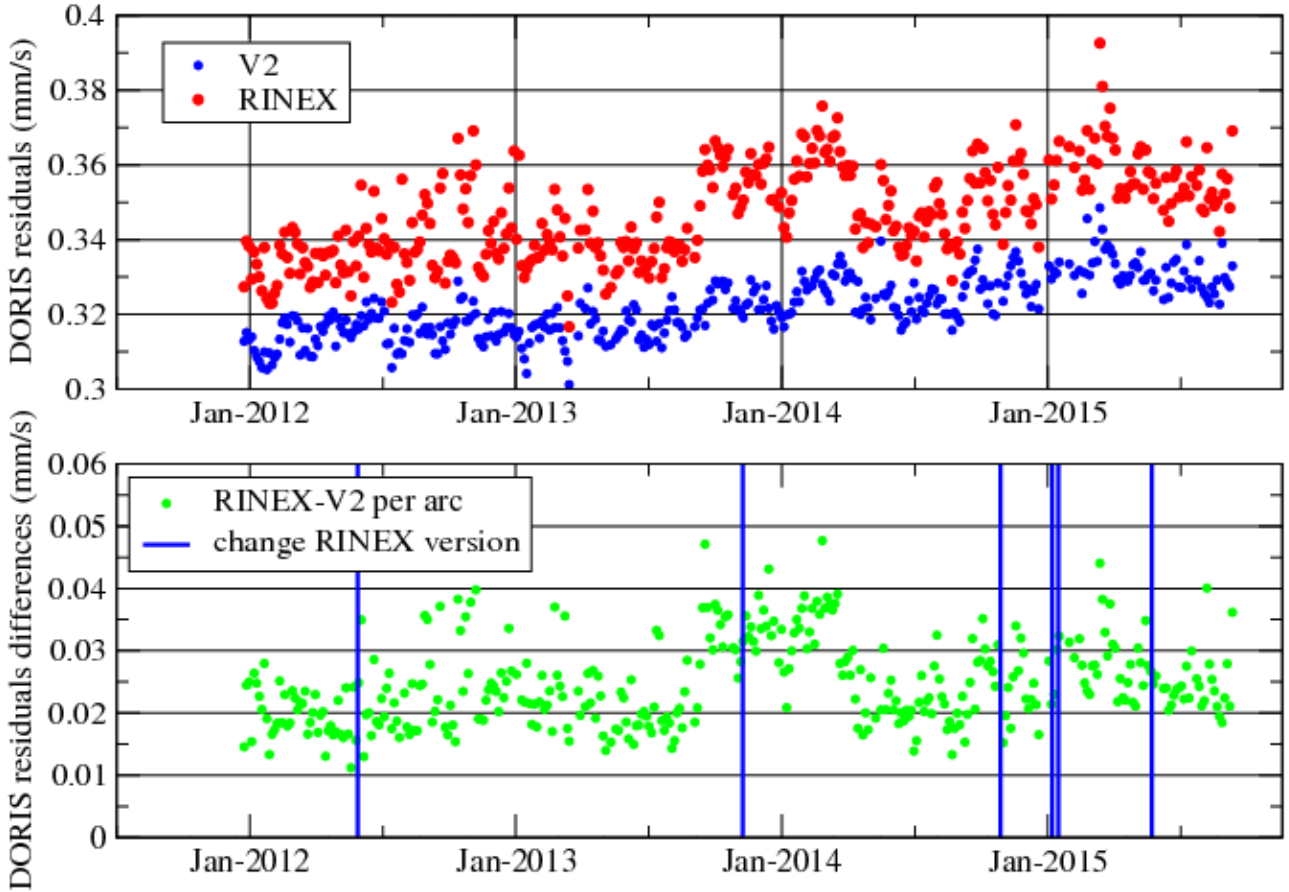
$\vec{r}_{400MHz,2GHz}$ is the vector from the 400 MHz to the 2 GHz phase center.

Ionospheric corrections

Unit = mm	Ref. point – 400 MHz	Ref. point – 2 GHz	400 MHz – 2 GHz	2 GHz – iono-free	Ref. point – iono-free
ALCATEL satellite antenna (SPOT-2)	160	355	195	8	363
STAREC satellite antenna (SPOT-3)	152	315	163	6	321
STAREC satellite antenna (SPOT-4)	155	316	161	6	322
STAREC satellite antenna (SPOT-5)	153	315	162	6	321
STAREC satellite antenna (TOPEX)	161	317	156	6	323
STAREC satellite antenna (ENVISAT)	153	318	165	6	324
STAREC satellite antenna (Jason-1)	156	324	168	7	331
STAREC satellite antenna (Jason-2)	155	319	164	6	325
STAREC satellite antenna (Cryosat-2)	158	312	154	6	318
STAREC satellite antenna (HY-2A)	154	316	162	6	322
STAREC satellite antenna (SARAL)	156	314	158	6	320
ALCATEL ground antenna	335	510	175	7	517
STAREC ground antenna	0	487	487	19	506

Jason-2 DORIS RMS residuals

Jason-2 GRG Processing with ITRF2014 (with post seismic model)
DORIS data: DORIS2.2 (V2) and RINEX files from CDDIS
Time span processing: January 2012 to September 2015



Jason-2 orbit comparison (RINEX vs DORIS2.2)

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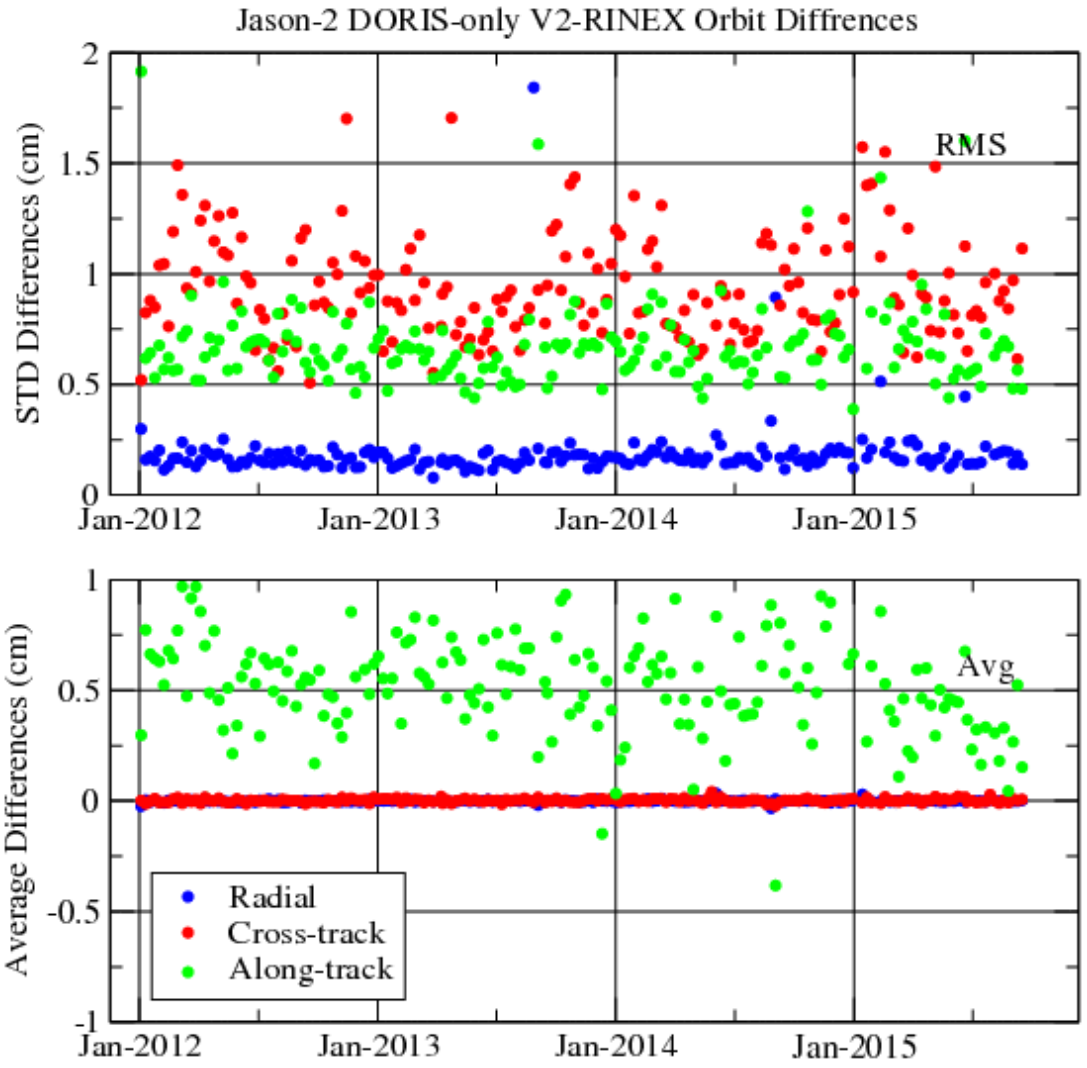

CONCLUSIONS

Jason-2 DORIS RMS residuals

• Jason-2 DORIS residuals are higher when we process RINEX data

This is understood and has been explained by Jean-Michel presentation at AWG in Greenbelt in October:

http://ids-doris.org/images/documents/report/AWG201510/IDSAWG201510-JMLemoine-ExplanationRMSdifferenceDORIS2.2RINEXPANDOR.pdf

It is due of a problem of time-tagging of the RINEX data

• the DORIS residuals differences between doris2.2 (V2) and RINEX are around [0.02-0.03] mm/s

• GRG AC is going to wait a new version of PANDOR RINEX files taking into account the correction proposed by Jean-Michel before to do new tests

Jason-2 orbit comparison (RINEX data compared to DORIS2.2 data)

• There is an offset of 0.2 cm in the STD radial orbit differences

• There is an offset of 0.5 cm in the Along-track orbit differences

• There is a slight reduction of the Along-track bias when using RINEX from PANDOR (after January 2015)

Jason- 2 positioning results from RINEX data files

• As shown at the AWG in Toulouse in May the quality with DORIS RINEX data is at the same level than DORIS2.2 data

(see http://ids-doris.org/images/documents/report/AWG201505/IDSAWG201505-Lemoine-RINEXprocessingGRG.pdf)