Explanation of the difference in rms residuals between DORIS-2.2 and RINEX-PANDOR data

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1- Difference in rms between DORIS-2.2 and DORIS-RINEX (PANDOR time-tagged) data sets

- Test arc : one 5-day arc of Jason-2, starting on 2010/03/22 (Jul1950 = 21995)

- The number of raw and valid measurements is different between the two sets because of:
  - different elevation cut-off strategies,
  - different editing strategies (i.e. flagging of the measurements at zero Doppler…)

➔ **The rms of residuals are necessarily different:**
(in black: DORIS-2.2, in red: RINEX-PANDOR)

DOR-2.2 / RINEX	rms		# Valid meas.		# Edited meas.		# Total meas.	
DORIS (mm/s)	**0.3192**	**0.3338**	**73563**	**74358**	**35518**	**49235**	**109161**	**123593**
SLR (cm)	**2.082**	**2.328**	**1939**	**1911**	**76**	**104**	**2015**	**2015**
ALTIM xover (cm)	**4.159**	**4.106**	**1440**	**1426**	**19**	**33**	**1459**	**1459**

Nota: The SLR and Xover measurements are strongly down-weighted. They are present only for validation purposes and do not participate in the computation of the orbit.

2- Homogeneous data flagging between DORIS-2.2 and DORIS-RINEX (PANDOR time-tagged) data sets

➔ In order to compare the residuals meaningfully, a homogeneous data flagging has been applied to DORIS-2.2 and RINEX-PANDOR measurements by combining the flags of both data sets. Only the measurements valid in both data sets are kept.

The rms of residuals are still different between DORIS-2.2 and RINEX-PANDOR:
(in black: DORIS-2.2, in red: RINEX-PANDOR)

DOR-2.2 / RINEX	rms		# Valid meas.	
DORIS (mm/s)	**0.3177**	**0.3225**	**71213**	**71250**
SLR (cm)	**2.047**	**2.127**	**1936**	**1935**
ALTIM xover (cm)	**4.148**	**4.142**	**1440**	**1440**

3- PANDOR time-tagging of the DORIS-RINEX data set

The remaining difference in rms comes from the PANDOR time-tagging of the RINEX data: for some yet unidentified reason, the "Receiver Clock Offset" (RCO) field in the RINEX-PANDOR data is not smooth enough on the short term.

➔ This results in a fluctuation of the Doppler count duration which translates integrally into short-term noise.

Example of Doppler count measurement

in the DORIS-2.2 files:

Day	*Second*	*Count duration*
21997	42338.85557200	9.99999970
21997	42348.85557100	9.99999970
21997	42358.85557100	9.99999970
21997	42368.85557100	9.99999970
21997	42378.85557000	9.99999970
21997	42388.85557000	9.99999970
21997	42398.85557000	9.99999970
21997	42408.85556900	9.99999970
21997	42418.85556900	9.99999970

in the RINEX-PANDOR files:

Day	*Second*	*Count duration*
21997	42338.85557110	9.99999954
21997	42348.85557064	9.99999985
21997	42358.85557049	9.99999954
21997	42368.85557003	9.99999954
21997	42378.85556957	9.99999985
21997	42388.85556942	9.99999954
21997	42398.85556896	9.99999985
21997	42408.85556882	9.99999954
21997	42418.85556836	9.99999985

4- The "Receiver Clock Offset" field in the DORIS-RINEX files

Document: RINEX DORIS 3.0 (Issue 1.7) (ftp://ftp.ids-doris.org/pub/ids/data/RINEX_DORIS.pdf)

A 2 GNSS OBSERVATION DATA FILE - DATA RECORD DESCRIPTION

TABLE A2
GNSS OBSERVATION DATA FILE - DATA RECORD DESCRIPTION

DESCRIPTION	FORMAT
EPOCH record	
- Record identifier : >	A1,
- Epoch :	
- year (4 digits)	1X,I4,
- month,day,hour,min (two digits)	4(1X,I2.2),
- sec	F13.9,
- Epoch flag	2X,I1,
0: OK	
1: power failure between previous and current epoch	
>1: Special event	
- Number of stations observed in current epoch	I3,
(reserved)	6X,
- Receiver clock offset (seconds, optional)	F13.9,
- Receiver clock offset flag,	1X,I1,1X
1 if extrapolated, 0 otherwise	

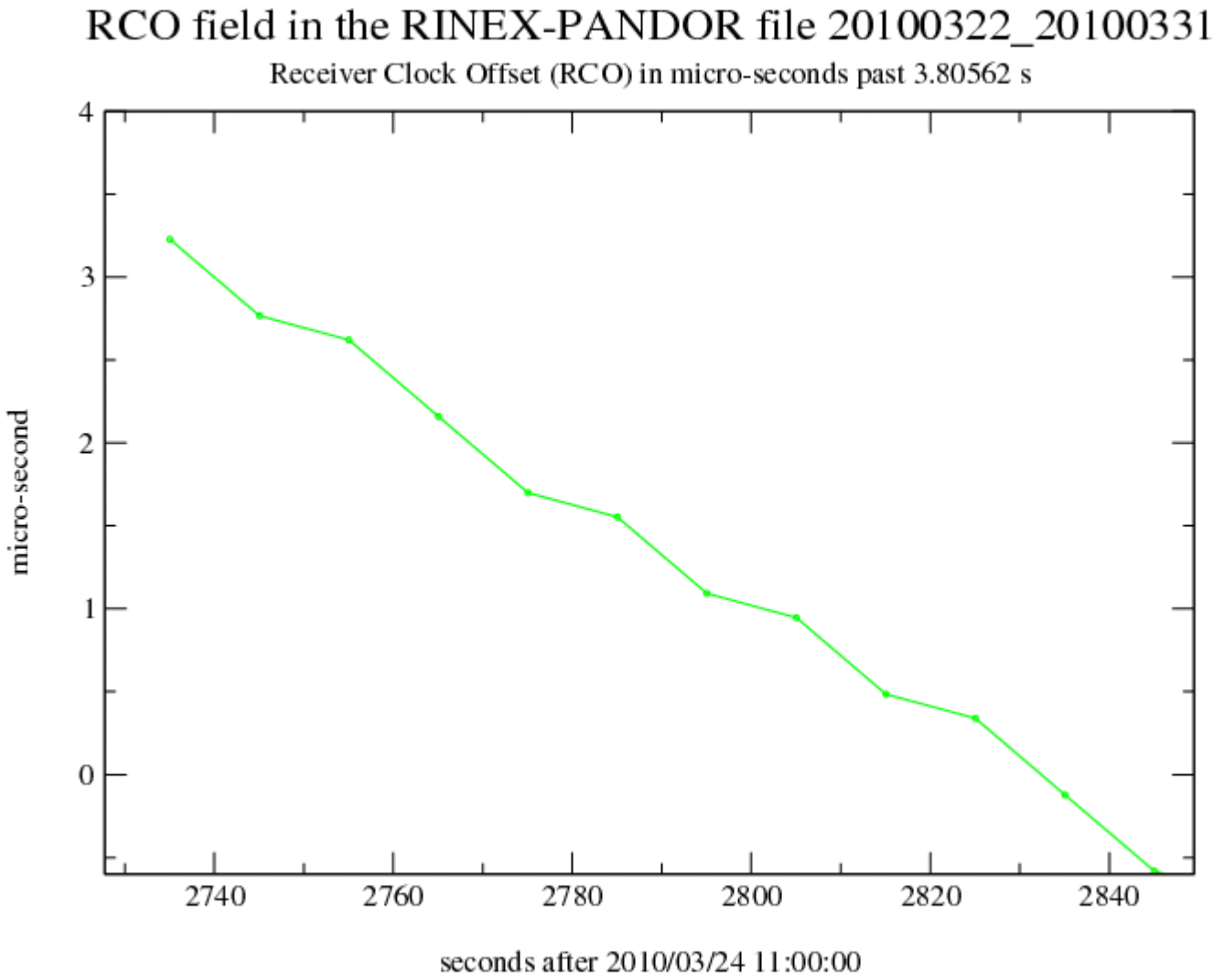
4- Examples of RCO field in the DORIS-RINEX files

	Year	Mo	Day	H	M	S		#Sta	RCO	
>	2010	03	24	11	45	35.049947870	0	7	3.805623228	0
>	2010	03	24	11	45	38.049947870	0	7	3.805623059	0
>	2010	03	24	11	45	45.049947870	0	7	3.805622767	0
>	2010	03	24	11	45	48.049947870	0	7	3.805622598	0
>	2010	03	24	11	45	55.049947870	0	7	3.805622621	0
>	2010	03	24	11	45	58.049947870	0	7	3.805622451	0
>	2010	03	24	11	46	5.049947870	0	7	3.805622160	0
>	2010	03	24	11	46	8.049947870	0	7	3.805621991	0
>	2010	03	24	11	46	15.049947870	0	6	3.805621700	0
>	2010	03	24	11	46	18.049947870	0	6	3.805621844	0
>	2010	03	24	11	46	25.049947870	0	6	3.805621553	0
>	2010	03	24	11	46	28.049947870	0	6	3.805621384	0
>	2010	03	24	11	46	35.049947870	0	6	3.805621093	0
>	2010	03	24	11	46	38.049947870	0	6	3.805621237	0
>	2010	03	24	11	46	45.049947870	0	6	3.805620946	0
>	2010	03	24	11	46	48.049947870	0	6	3.805620777	0
>	2010	03	24	11	46	55.049947870	0	6	3.805620485	0
>	2010	03	24	11	46	58.049947870	0	6	3.805620316	0
>	2010	03	24	11	47	5.049947870	0	6	3.805620339	0

➔ *Irregular decrease of the RCO, and even sometimes increase (blue arrows)*

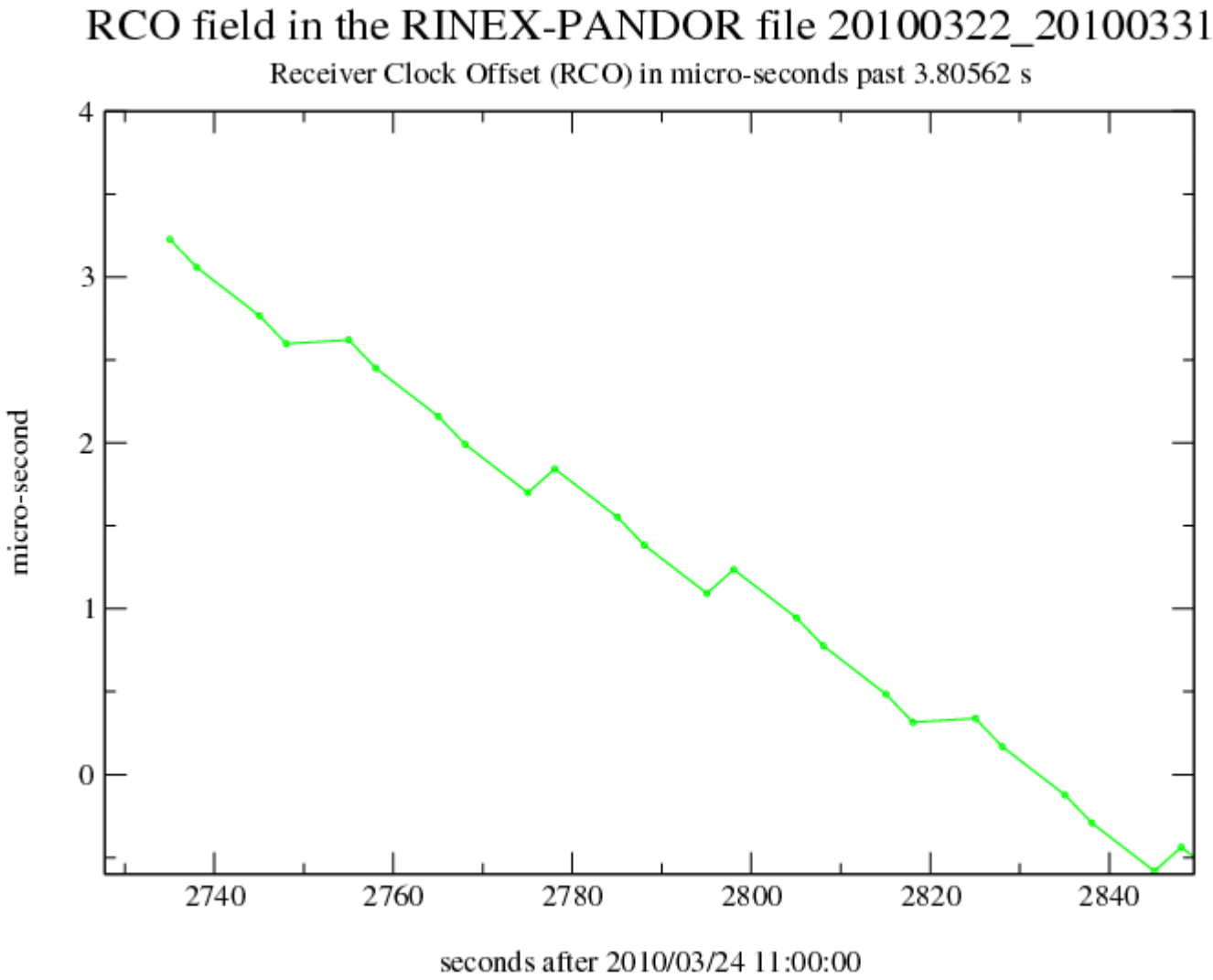
4- Examples of RCO field in the DORIS-RINEX files

(Measurements every 10 s)



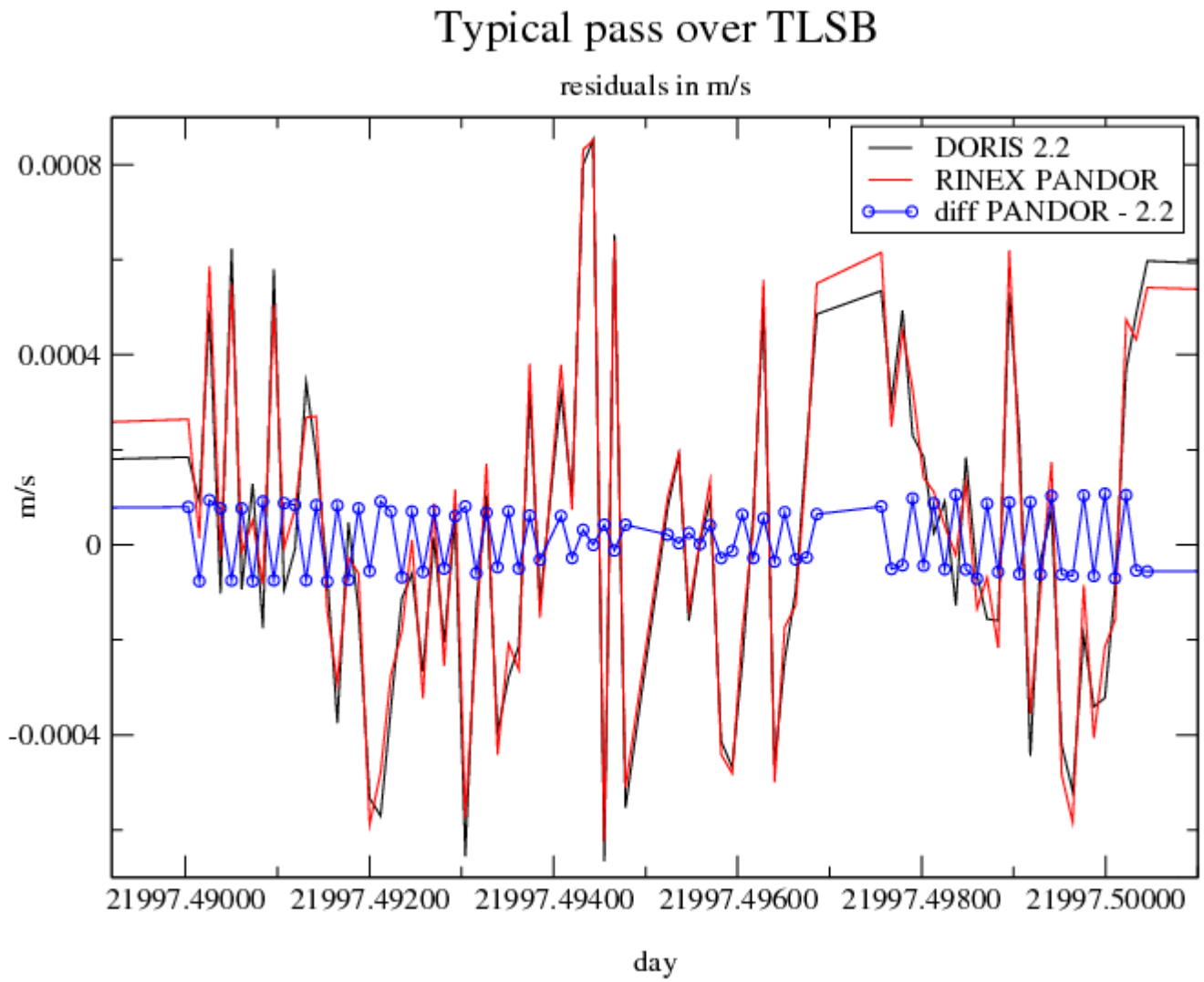
4- Examples of RCO field in the DORIS-RINEX files

(Measurements every 3 and 7 s)



5- Effect on the Doppler residuals

In blue, the difference between the DORIS-2.2 and the RINEX-PANDOR residuals for a typical pass over the Toulouse beacon. The blue curve is 100 % additional noise.



6- Comparison of rms once the PANDOR time-tagging is corrected

➔ For test purposes, a uniform duration of the Doppler count has been applied in replacement for the one provided by the PANDOR time-tagging.

The rms of residuals are now quasi-identical:
(in black: DORIS-2.2, in red: RINEX-PANDOR)

DOR-2.2 / RINEX	rms		# Valid meas.	
DORIS (mm/s)	**0.3177**	**0.3174**	**71213**	**71209**
SLR (cm)	**2.047**	**2.115**	**1936**	**1937**
ALTIM xover (cm)	**4.148**	**4.148**	**1440**	**1440**

7- Remaining difference in the SLR rms of residuals

The rms of the SLR residuals are still slightly higher for the RINEX-PANDOR file than for the DORIS-2.2 file:

(in black: DORIS-2.2, in red: RINEX-PANDOR)

DOR-2.2 / RINEX	rms		# Valid meas.	
DORIS (mm/s)	**0.3177**	**0.3174**	**71213**	**71209**
SLR (cm)	**2.047**	**2.115**	**1936**	**1937**
ALTIM xover (cm)	**4.148**	**4.148**	**1440**	**1440**

➔ The reason is a small offset of 0.6 10^{-6} s between the DORIS-2.2 (POD) time-tagging and the PANDOR time-tagging, leading to an along-track difference in position of 4 mm *(for this particular arc).*

This is within the normal uncertainty of the time-tagging; **but in both cases, there is still a 1.8 cm along-track difference between the DORIS and the SLR measurements…**

Conclusions

- Once the editing strategy has been harmonized between the DORIS-2.2 and the DORIS-RINEX measurements files, the difference in rms between the two types of data files can be fully explained by a short-term noise present in the PANDOR-timed-tagged data, similar to a rounding error somewhere in the PANDOR process.
- This noise in the PANDOR time-tagging has an amplitude of some tenths of microseconds and results in an additional noise on the relative velocity measurement of +/- 0.1 mm/s for Jason-2.
- Apart from this short-term noise, the time-tagging is coherent between the POD processed data (DORIS-2.2) and PANDOR within ~ 0.5 microsecond.
- For Jason-2 (in the GINS software at least…), there seems to be still an along-track bias of 1-2 cm between the DORIS and the SLR measurements, which needs to be investigated.

Thank you for your attention