Use of DORIS RINEX Doppler measurement with the GINS software

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Outline

- Some reminders about the RINEX/DORIS files
- Comparison of results obtained from DORIS2.2 and RINEX/DORIS Doppler measurement over 4 months for Jason-2, Hy-2a, Cryosat-2, Saral
- Some results obtained with the upcoming version of the RINEX/DORIS including an improved dating from SSALTO ‘s component PANDOR
- Conclusion

About the RINEX/DORIS 3.0

- RINEX/DORIS 3.0 is a format derived from the RINEX/GPS format and adapted for the phase and pseudo-range measurements of the DGXX instruments

- RINEX/DORIS 3.0 will be the only format for the DORIS measurements of the next missions: Jason-3, Sentinel-3A,…

- RINEX/DORIS will be soon delivered with a dating computed by the SSALTO component PANDOR (instead of DIODE time tagging)

- A tutorial to help analysists to use RINEX/DORIS is in progress including:

- Description of the RINEX/DORIS content based on an example *(new document)*
- Reminder of data archive, naming conventions
- List of related technical notes, publications and presentations
- GINS routines to read RINEX files provided by J.M. Lemoine (CNES/GRGS)

Soon on IDS web site: **http://ids-doris.org**

RINEX/DORIS processing at CNES/CLS AC

***IDS Workshop 2008* - GINS software evolutions for the Jason-2 data processing: RINEX and DORIS 2.2 formats** (L. Soudarin)

-conversion of DORIS/RINEX phase measurements into cycle numbers to be processed as Doppler measurements

-orbit results with 1 day of Jason-2 data: comparison RINEX/DORIS and DORIS2.2 Doppler measurement

→ same orbit residual WRMS

→ 35 cm along–track differences but electronic propagation delay not taken into account; this led to a correction of the files and a new delivery to DCs.

***IDS Workshop 2012* - Implementation and use of the DORIS RINEX phase measurement in the GINS software** (J.M. Lemoine)

- DORIS2.2 and RINEX/DORIS Doppler measurement + RINEX/DORIS ambiguous phase measurement

-results with 3 weeks of Jason-2, Hy-2a, Cryosat-2 data

→ DORIS phase measurement results seemed too good to be true

→ Scale factor differences between DORIS2.2 and RINEX/DORIS Doppler measurement: ~20 mm

This study: DORIS2.2 vs RINEX/DORIS 3.0

Question: is the scale factor difference confirmed over a longer period?

For this study, we analyzed Cryosat-2, Jason-2, Hy-2A and Saral data over a 4 months period from September to December 2013 (17 weeks) with 3.5-day arcs and a cut-off angle of 12°

We consider 2 cases :

- DORIS2.2 Doppler measurement
- RINEX/DORIS 3.0 phase measurement converted to Doppler

DORIS2.2 vs RINEX/DORIS: orbit fit residuals

Mean of WRMS residuals for the Doppler computations

34 arcs, 8 arcs with important residuals excluded for SARAL

Orbit residuals WRMS + data used (+% edited data)

satellite	DORIS2.2	RINEX/DORIS
Cryosat-2	0.352 mm/s 29172 (39%)	0.364 mm/s 30610 (38%)
HY-2A	0.331 mm/s 37517 (35%)	0.339 mm/s 39332 (34%)
Jason-2	0.322 mm/s 54828 (32%)	0.327 mm/s 58326 (32%)
Saral	0.345 mm/s 30816 (42%)	0.383 mm/s 31647 (50%)

→Higher residuals with DORIS/RINEX but more data; same % of edited data

→ Saral data processing still to be improved

DORIS2.2 vs RINEX/DORIS: orbit comparison

Mean of orbit differences arc by arc (RINEX –DORIS2.2)

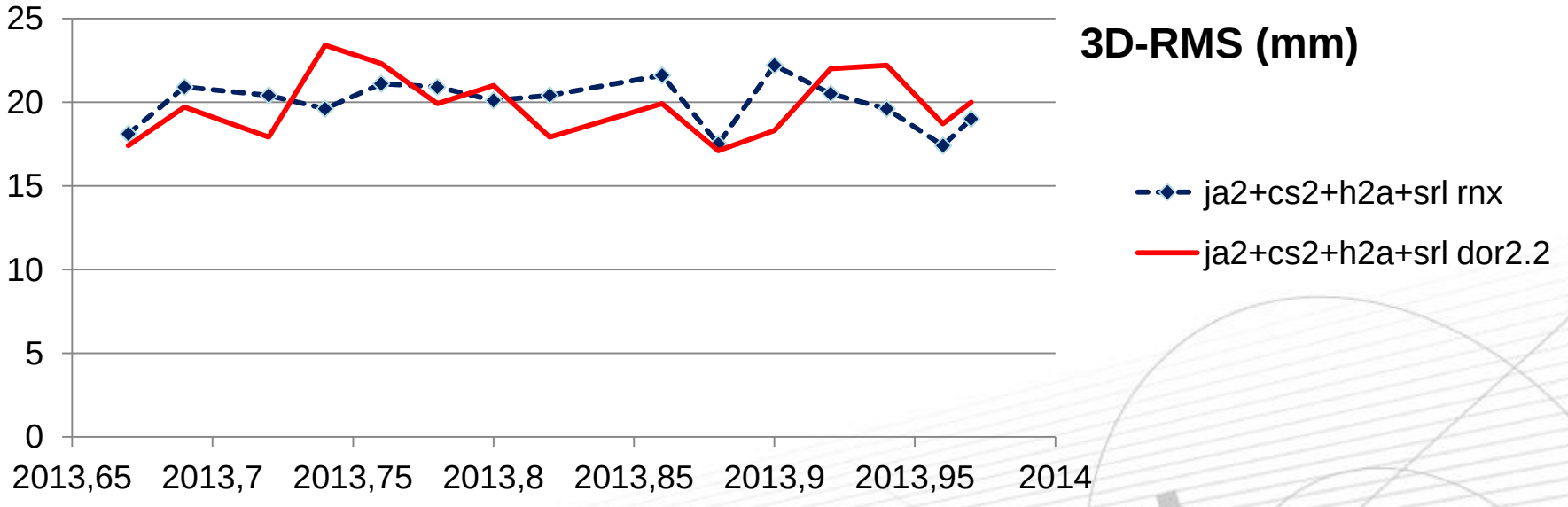
(8 arcs with important residuals excluded for SARAL)

	Bias (mm)			Std Dev (mm)			
satellite	Radial	Cross-Tr	Along-Tr	Radial	Cross-Tr	Along-Tr	3D-RMS
Cryosat-2	0,0	0,0	-16,5	1,0	1,9	6,1	6,5
HY-2A	0,0	0,0	-11,9	1,1	2,7	6,4	7,3
Jason-2	0,0	0,0	-4,0	1,5	4,9	5,0	7,8
Saral	0,0	0,0	-10,3	1,2	2,8	6,9	7,7

→ Bias along-track of about 1 cm; coherent with the precision of DIODE time tagging (~1.10^{-6} s rms)

Station network estimation: positions

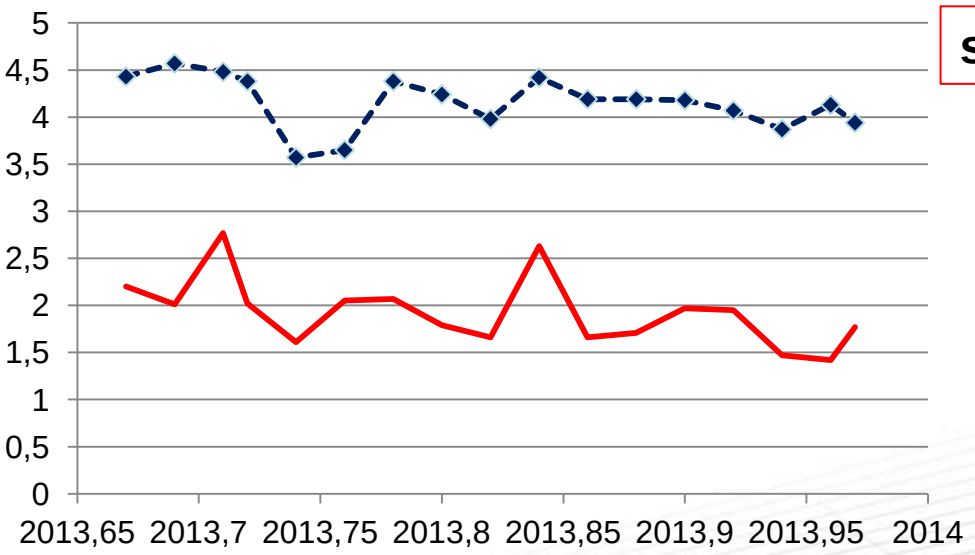
- DORIS 2.2 and RINEX multi-satellite solutions (Ja2+Cs2+H2a+Srl)
- Comparison to ITRF2008



RMS (mm)	DORIS 2.2	RINEX/DORIS
North	18,52	18,13
East	20,81	21,13
Up	19,85	20,31

Station network estimation: scale factor

- DORIS 2.2 and RINEX multi-satellite solutions (Ja2+Cs2+H2a+Srl)
- Comparison to ITRF2008



scale (ppb)

ja2+cs2+h2a+srl rnx

ja2+cs2+h2a+srl dor2.2

NB: period of this study included in period of high scale values

Average scale:

DORIS2.2 : +1.93 ppb

DORIS/RINEX: +4.16 ppb

→Larger scale with DORIS/RINEX

→Scale difference ~+2,2 ppb i.e. ~+14 mm (a bit less than obtained by JM Lemoine)

Station network estimation: scale factor by satellite

- Single-satellite solutions: DORIS 2.2, RINEX
- Comparison to ITRF2008

scale (ppb)	satellite	DORIS2.2	RINEX/DORIS
	Cryosat-2	+0.40 ppb	+1.21 ppb
	HY-2A	+0.89 ppb	+1.93 ppb
	Jason-2	+0.46 ppb	+1.08 ppb
	Saral	+0.62 ppb	+1.80 ppb

→Single-satellite solutions show smaller scales that the multi-satellite combination
→Scale difference: < 1.2 ppb (~8 mm)

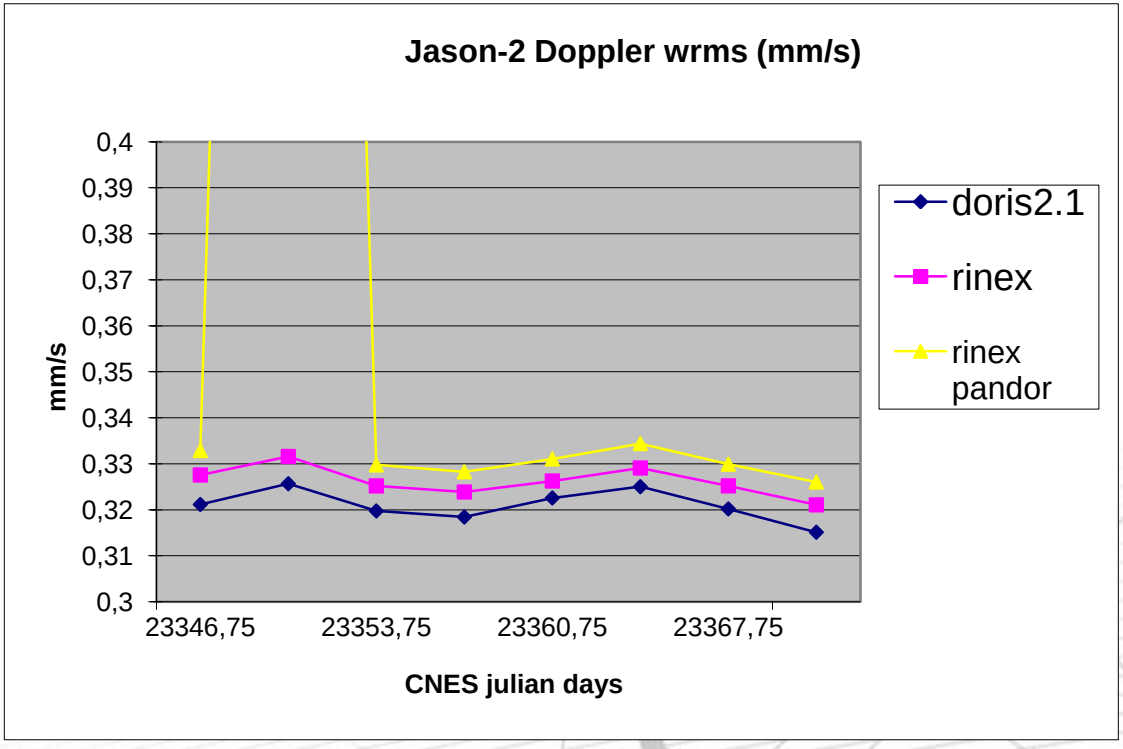
More investigations needed.

RINEX/DORIS 3.0 PANDOR: Orbit residuals

Test on 1 month (Dec. 2013)
3 satellites:
Cryosat-2, Jason-2, HY-2A

Anomaly on Dec. 6:
epoch differences between RINEX and RINEX/PANDOR = 1 ms !
(linked to a time reference beacon change)

Orbit fit residuals for Jason-2



WRMS (mm/s)	Cryosat-2	Jason-2	Hy2a
DORIS2.2	0,350	0,321	0,330
RINEX	0,357	0,326	0,338
RINEX/PANDOR	0,363	0,330	0,344

→orbit residuals larger for RINEX/PANDOR

RINEX/DORIS 3.0 PANDOR: orbit comparison

Mean of orbit differences arc by arc

		Bias (mm)			Std Dev (mm)			
	satellite	Radial	Cross-Tr	Along-Tr	Radial	Cross-Tr	Along-Tr	3D-RMS
RINEX/PANDOR – DORIS2.2	Cryosat-2	0,0	0,0	-8,6	0,3	0,7	1,5	1,7
	HY-2A	0,0	0,0	-4,8	0,6	1,2	2,1	2,7
	Jason-2	0,0	0,0	-0,6	0,8	1,8	1,7	2,7
RINEX– DORIS2.2	Cryosat-2	0,0	0,0	-17,2	0,9	1,9	6,2	6,7
	HY-2A	0,0	-0,1	-9,6	1,2	2,2	6,6	7,3
	Jason-2	0,0	0,0	-1,5	1,1	2,5	3,1	4,3

→better agreement between DORIS2.2 and RINEX/PANDOR orbits

Conclusions

- When the DORIS/RINEX measurements are processed as Doppler measurements, the results are similar to those of DORIS2.2 measurements, except for the scale factor.

  Is it observed by other Analysis Centers?

- PANDOR time tagging: orbit residuals larger than with current DORIS/RINEX, but orbit differences smaller wrt DORIS2.2; (scale factor not investigated yet)

- Some anomalies detected in RINEX files. Maybe others are hidden.

  They will be detected only if the data are used.

THANK YOU