

GLONASS Satellite Orbit Modelling

R. Dach¹, A. Sušnik¹, A. Grahsl¹, A. Villiger¹,
D. Arnold¹, L. Prange¹, S. Schaer^{1,2}, A. Jäggi¹

¹ *Astronomical Institute, University of Bern, Switzerland*

² *Swiss Federal Office of Topographie, swisstopo*

Summary from IGS Workshop
Session #08: Orbit Modelling
03–07. July 2017, Paris, France

Overview

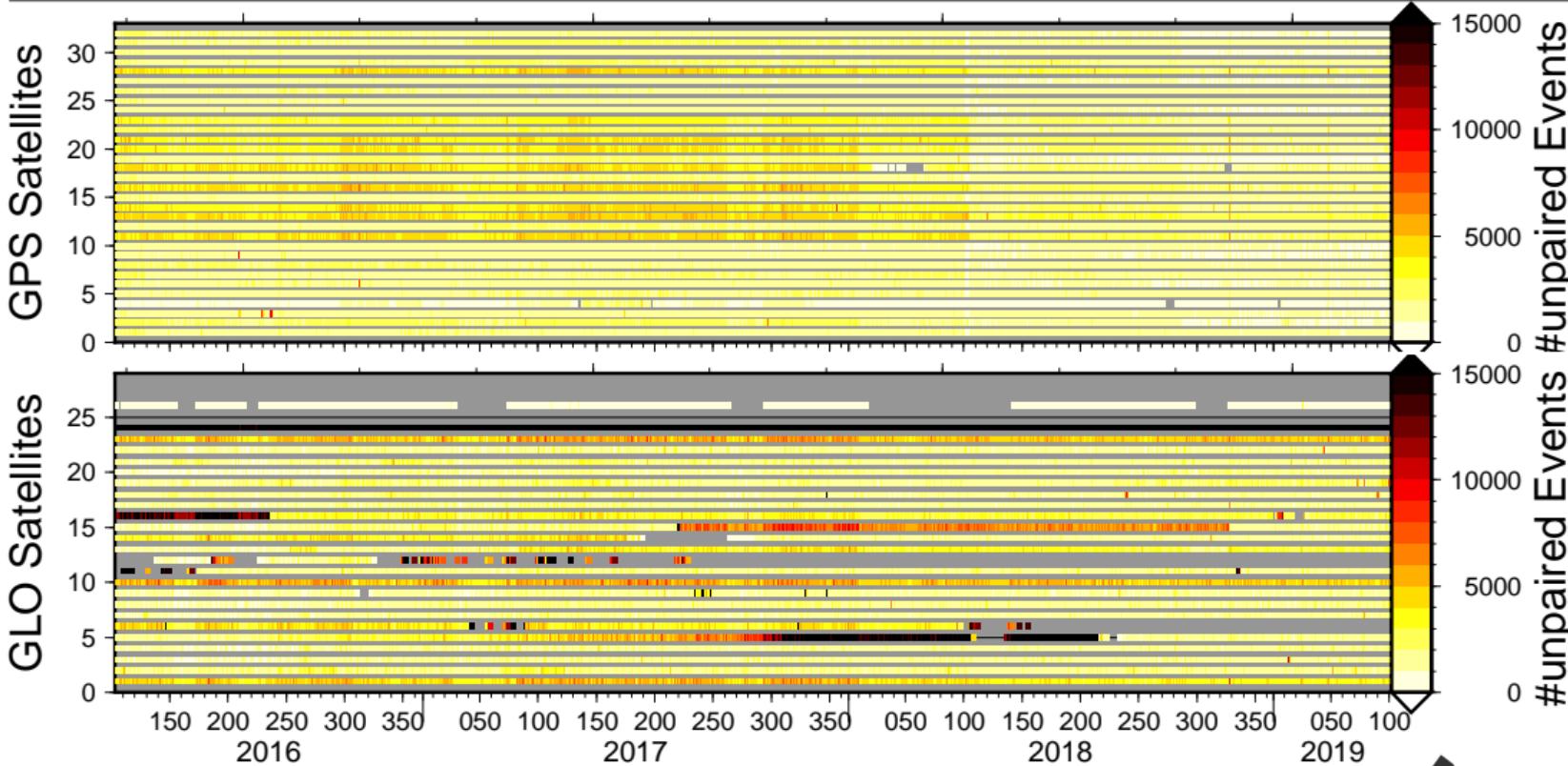
Data problem in GLONASS satellites

Re-estimating GLONASS SAOs

Applying the estimated satellite antenna offsets

Discussion and summary

Data problem in GLONASS satellites



Data problem in GLONASS satellites



Influence of station distribution on GNSS satellite orbits

IGSWS2016

International GNSS Service
Workshop 2016
8 - 12 February 2016, Sydney, Australia

u^b
in km/s



E. Ortiz Geist^{1,2}, R. Dach¹, F. Schönemann¹, W. Enderle¹, A. Jägg¹
¹Astronomical Institute, University of Bern, Bern, Switzerland
²Navigation Support Office, ESOC/ESA, Darmstadt, Germany

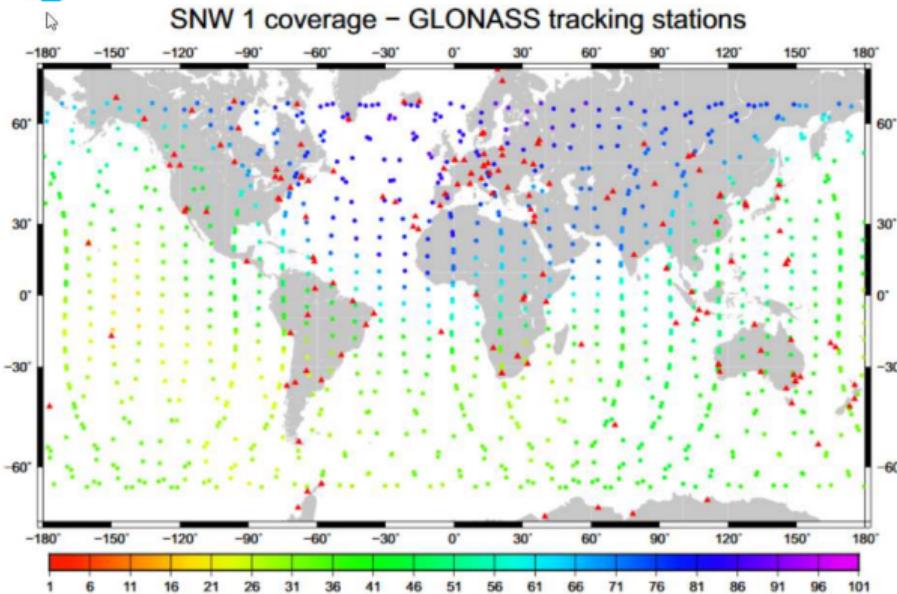


Fig. 4: SNW 1 coverage plot. The number of stations covering a particular GLONASS satellite - epoch wise- is given by the color from the scale bar.

Data problem in GLONASS satellites



Influence of station distribution on GNSS satellite orbits

IGSWS2016

International GNSS Service
Workshop 2016
8 - 12 February 2016, Sydney, Australia

u^b
for GNSS



E. Ortiz Geist^{1,2}, R. Dach¹, F. Schönemann¹, W. Enderle¹, A. Jägg²
¹Astronomical Institute, University of Bern, Bern, Switzerland
²Navigation Support Office, ESOC/ESA, Darmstadt, Germany

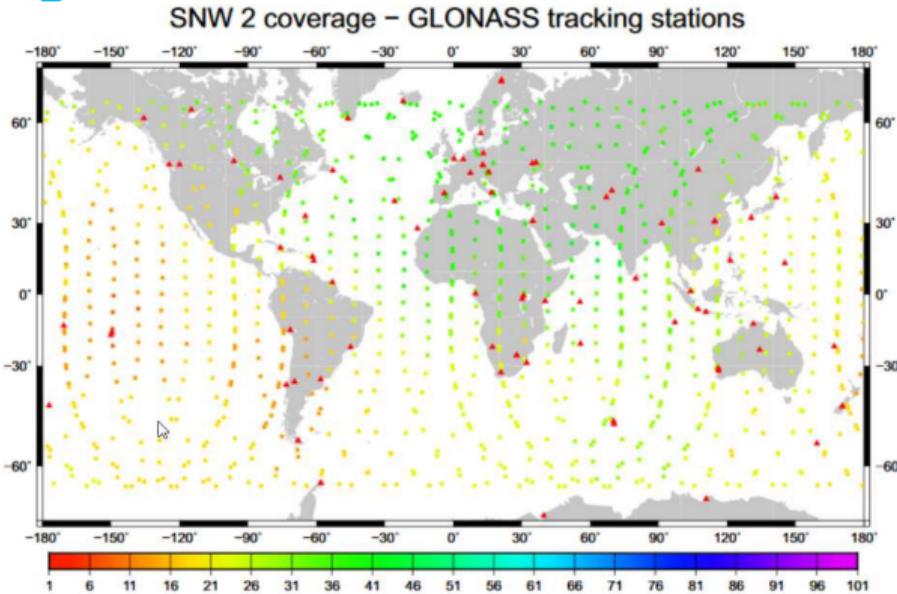


Fig. 5: SNW 2 coverage plot. The number of stations covering a particular GLONASS satellite - epoch wise- is given by the color from the scale bar.

Data problem in GLONASS satellites



Influence of station distribution on GNSS satellite orbits

IGSWS2016

International GNSS Service
Workshop 2016
8 - 12 February 2016, Sydney, Australia

u^b
in cm



E. Ortiz Geist^{1,2}, R. Dach¹, F. Schönemann¹, W. Enderle¹, A. Jägg¹
¹Astronomical Institute, University of Bern, Bern, Switzerland
²Navigation Support Office, ESOC/ESA, Darmstadt, Germany

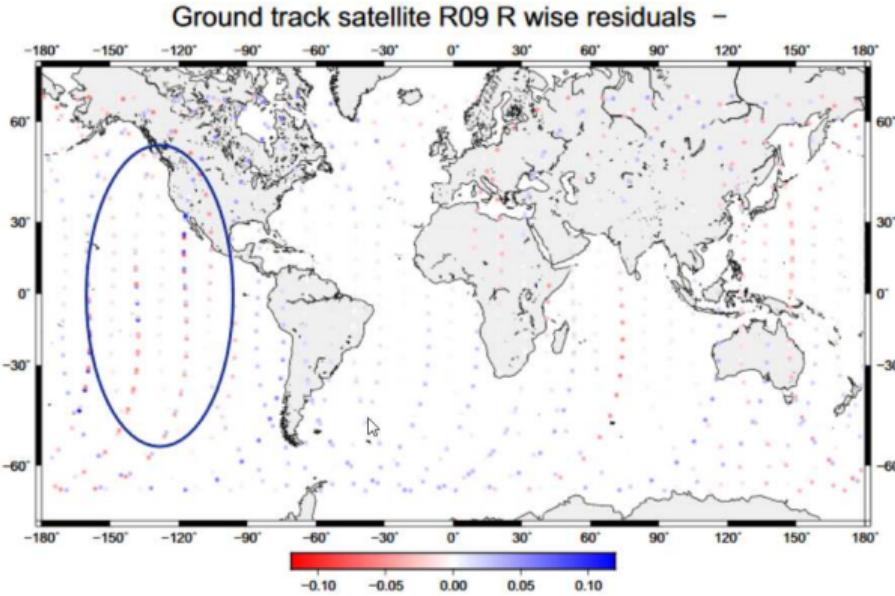


Fig. 10: Ground track residual from orbit solutions SNW1(CODE) and SNW2(CODE) - radial & epoch wise- plots for satellite R09. The color scale bar [12cm,-12cm] indicates the residual values.

Data problem in GLONASS satellites



Influence of station distribution on GNSS satellite orbits

IGSWS2016

International GNSS Service
Workshop 2016
8 - 12 February 2016, Sydney, Australia

u^b
in cm



E. Ortiz Geist^{1,2}, R. Dach¹, F. Schönemann¹, W. Enderle¹, A. Jägg¹
¹Astronomical Institute, University of Bern, Bern, Switzerland
²Navigation Support Office, ESOC/ESA, Darmstadt, Germany

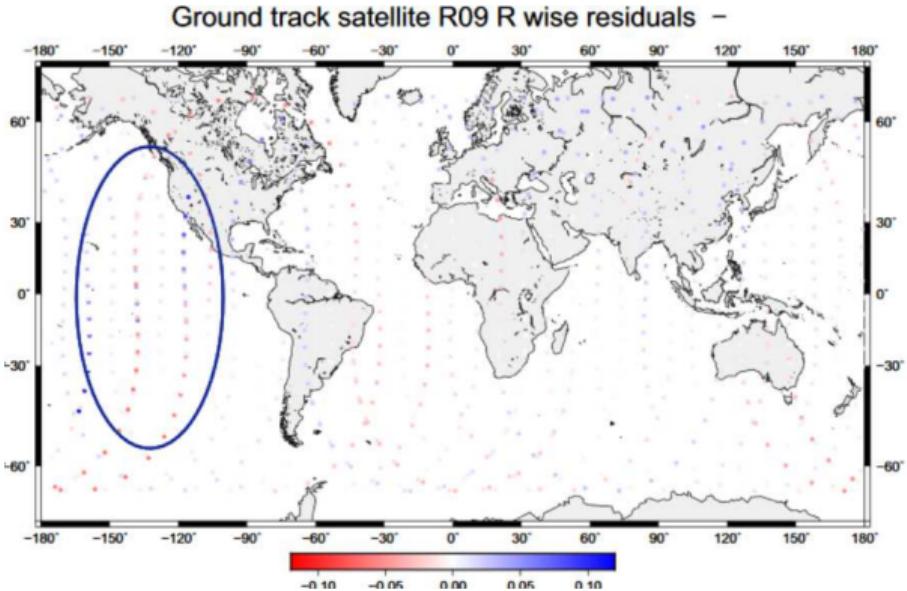
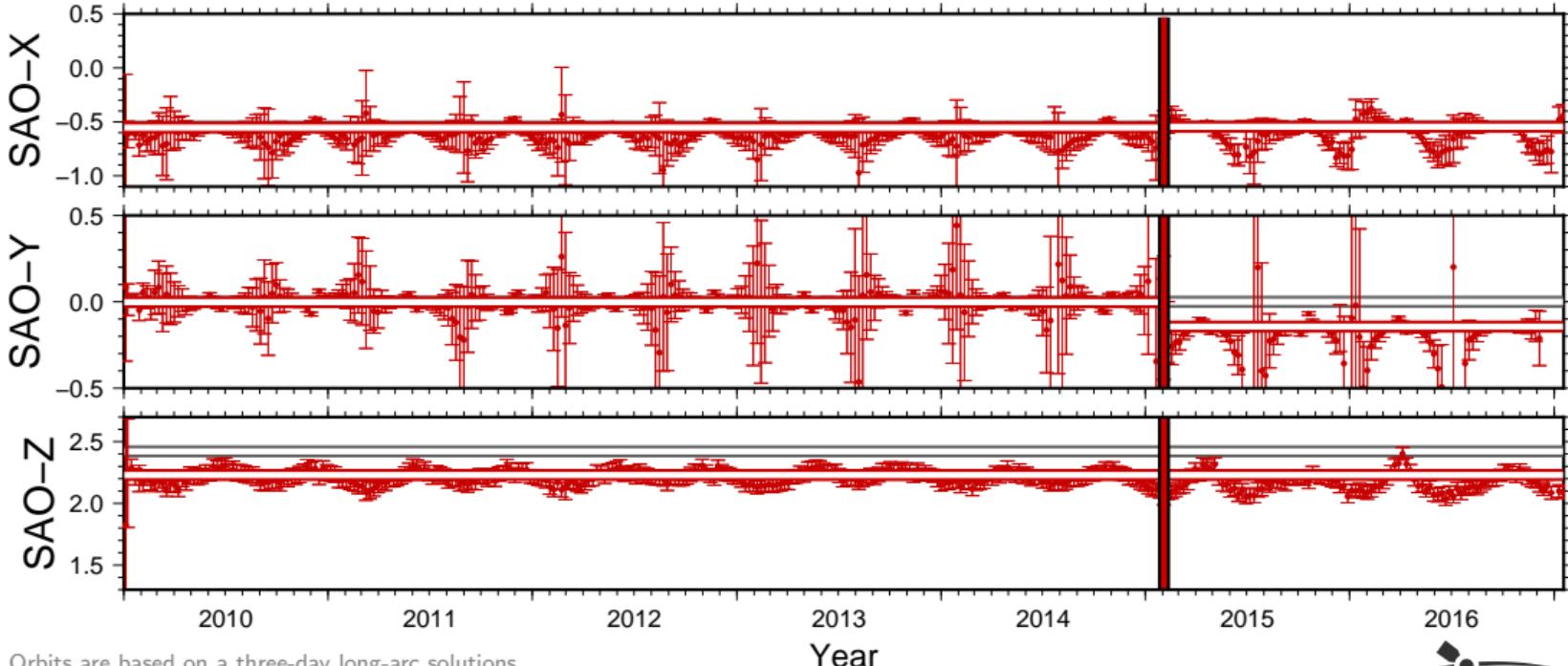


Fig. 11: Ground track residual from orbit solutions SNW1(ESOC) and SNW2(ESOC) - residual & epoch wise-plots for satellite R09. The color scale bar [12cm,-12cm] indicates the residual values.

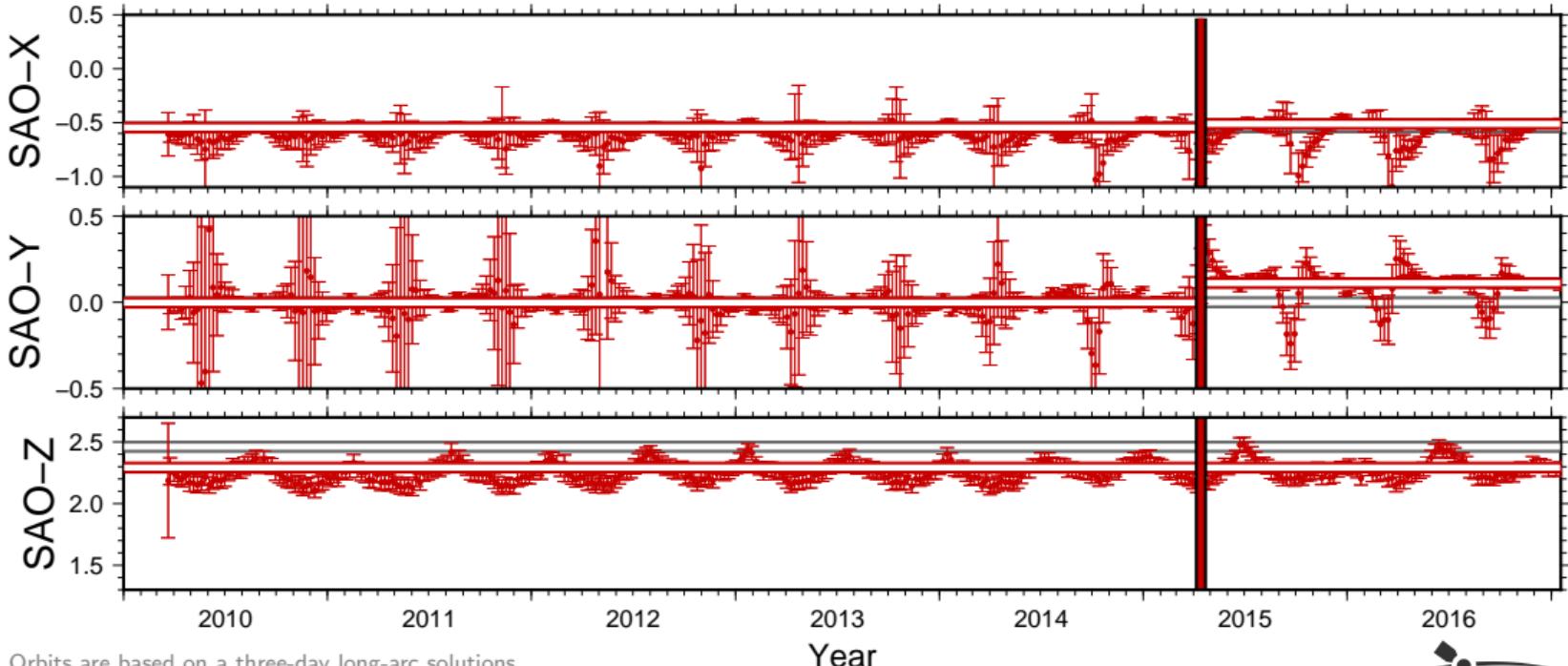
Re-estimating GLONASS SAOs

Estimated satellite antenna offsets (SAO) for satellite SVN 734 (R05) in m



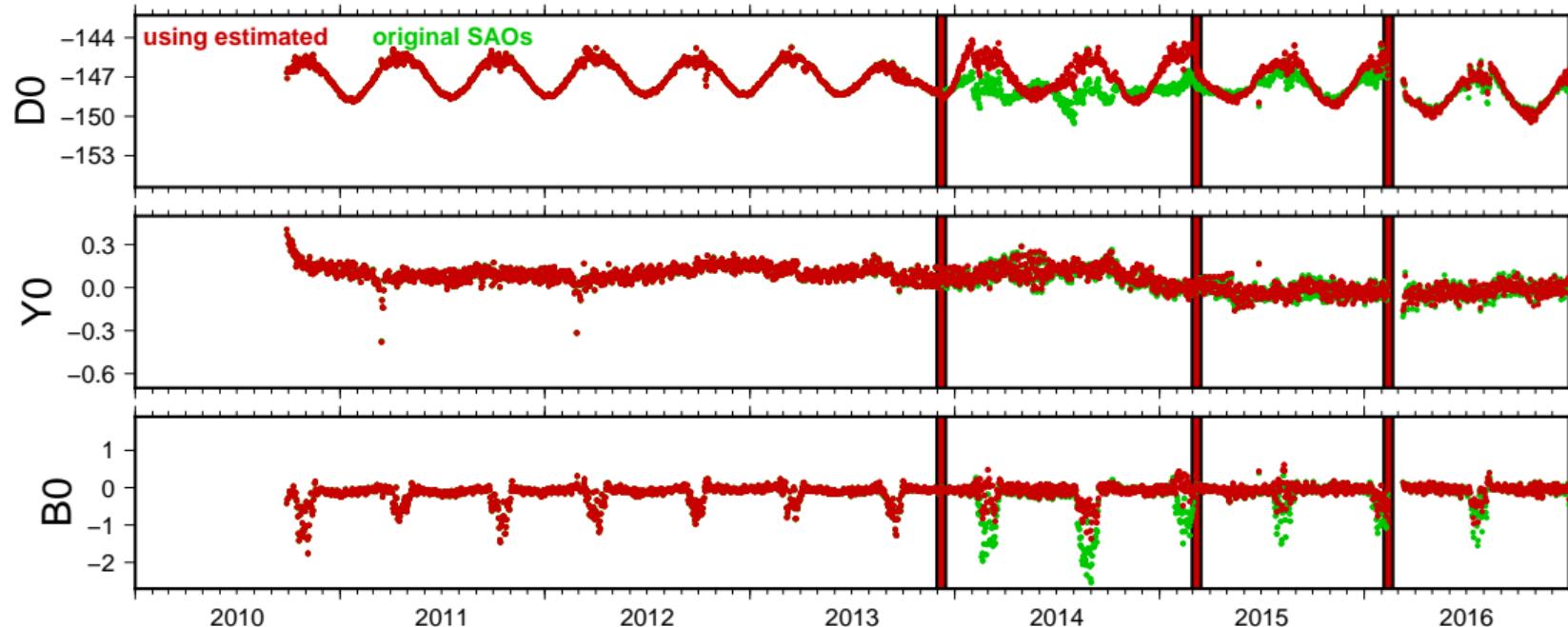
Re-estimating GLONASS SAOs

Estimated satellite antenna offsets (SAO) for satellite SVN 735 (R24) in m

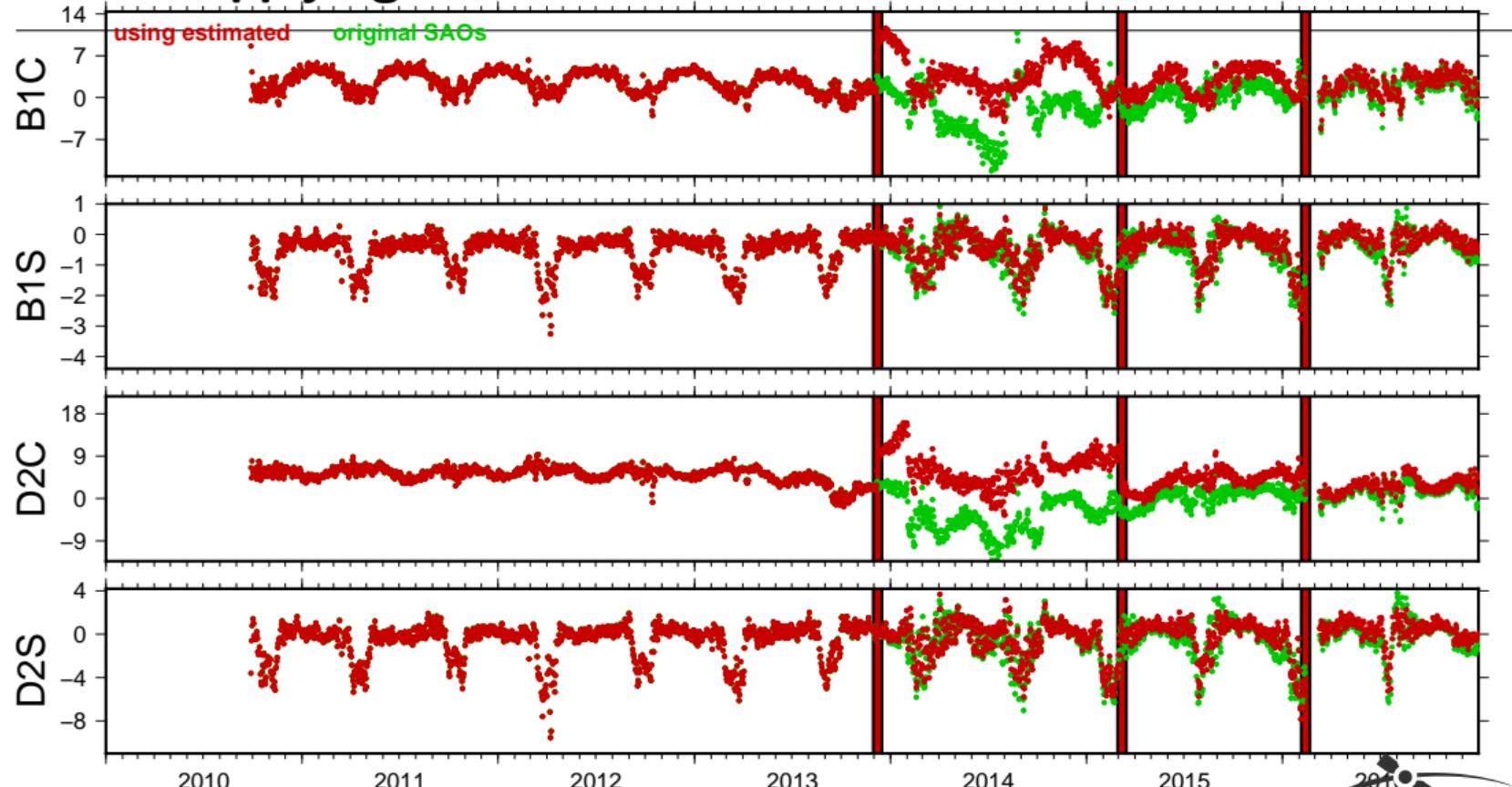


Applying the estimated satellite antenna offsets

Estimated SRP parameters for satellite SVN 736 (R09/R16) in nm/s²

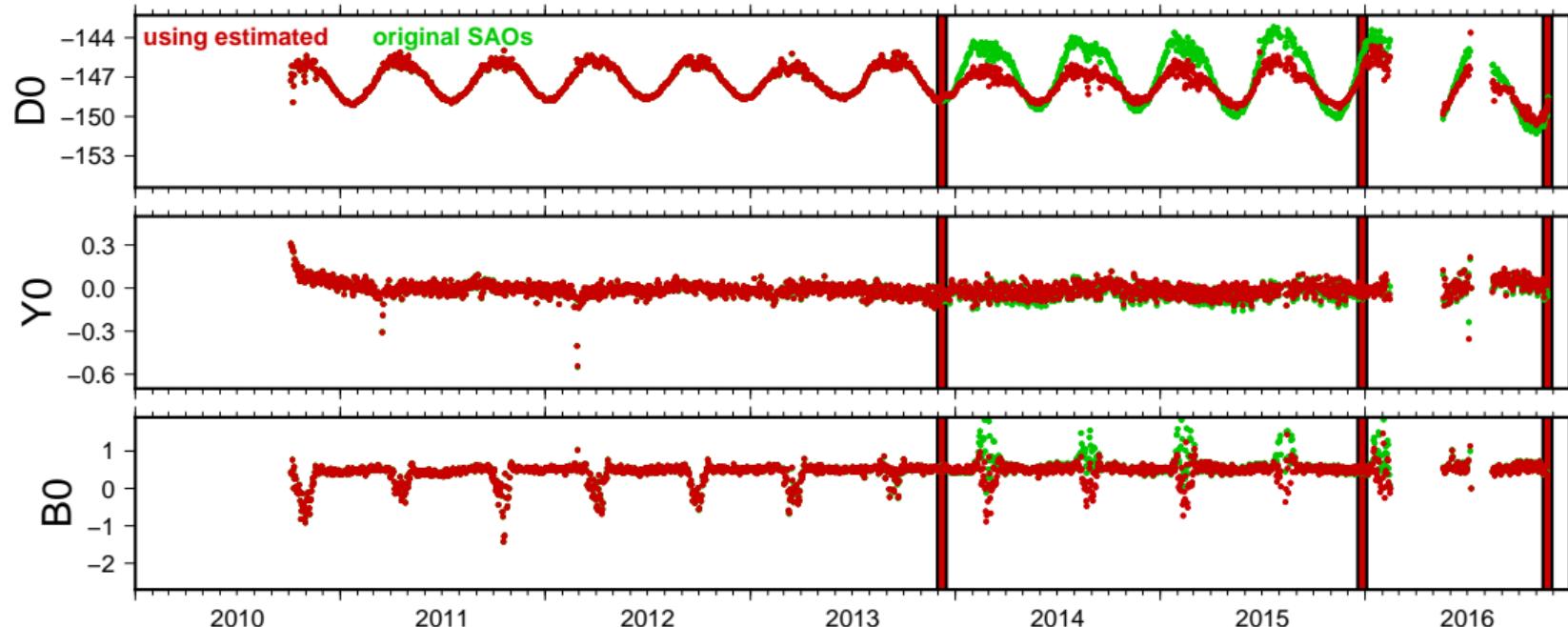


Applying the estimated satellite antenna offsets



Applying the estimated satellite antenna offsets

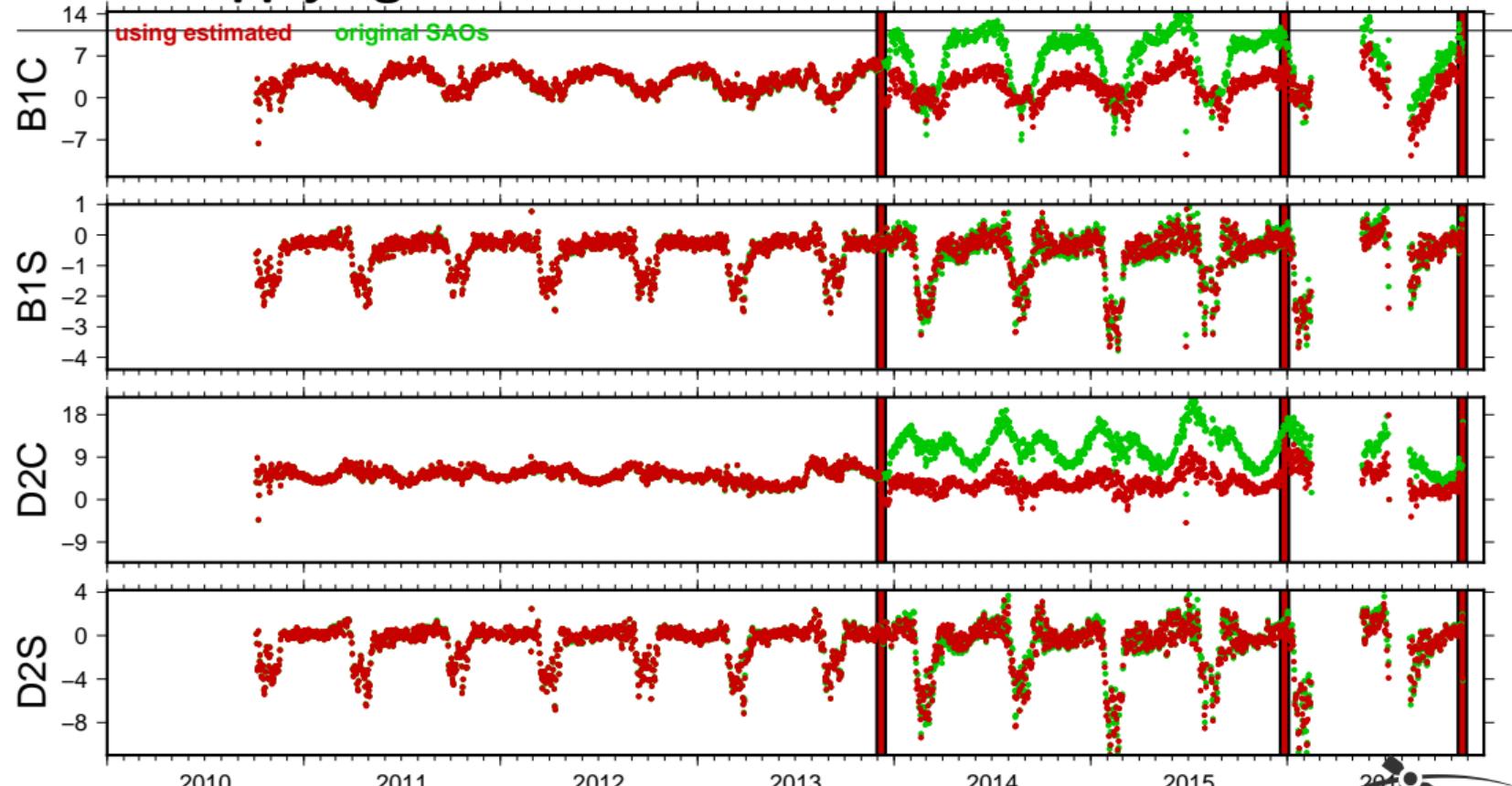
Estimated SRP parameters for satellite SVN 737 (R12) in nm/s²



R. Dach et al.: GLONASS Satellite Orbit Modelling
Summary from IGS Workshop, 03–07. July 2017, Paris, France

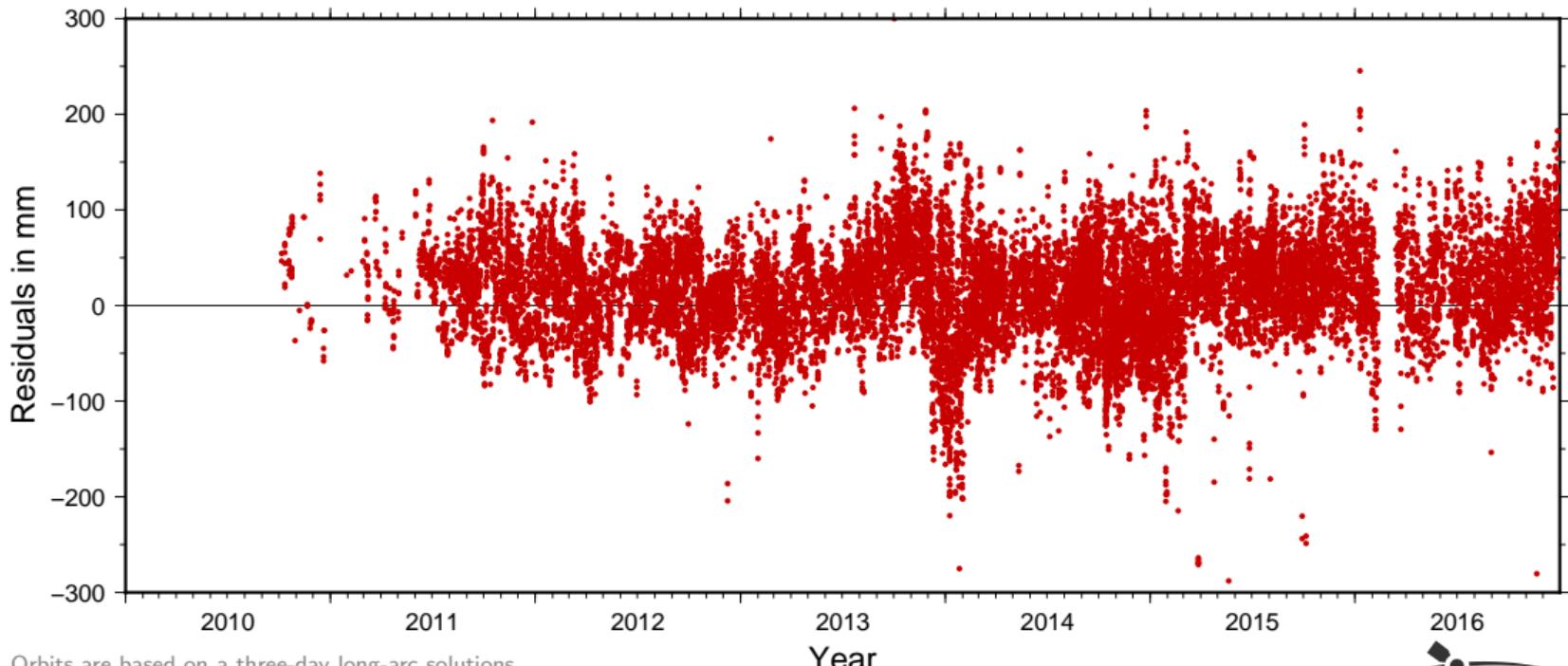
Orbits are based on a three-day long-arc solutions.

Applying the estimated satellite antenna offsets



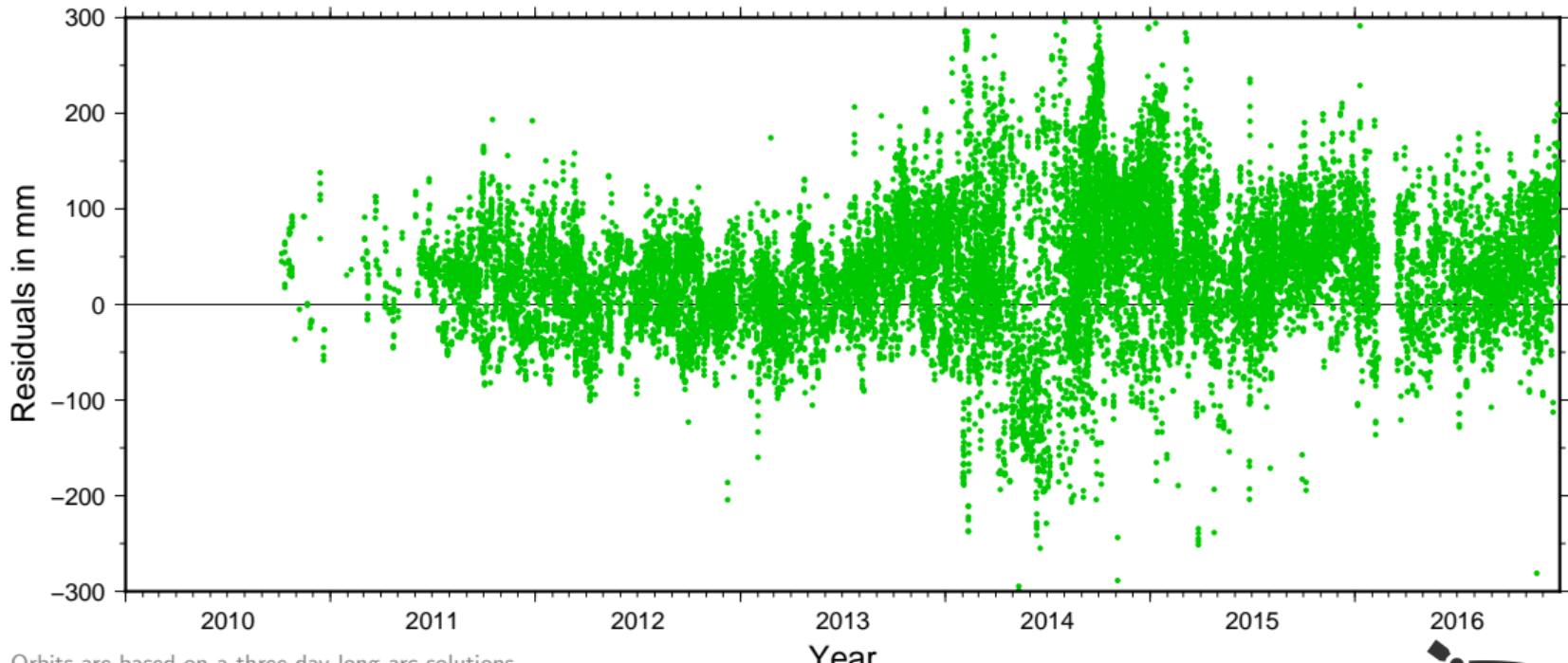
Applying the estimated satellite antenna offsets

SLR residuals for satellite SVN 736 (R09/R16)



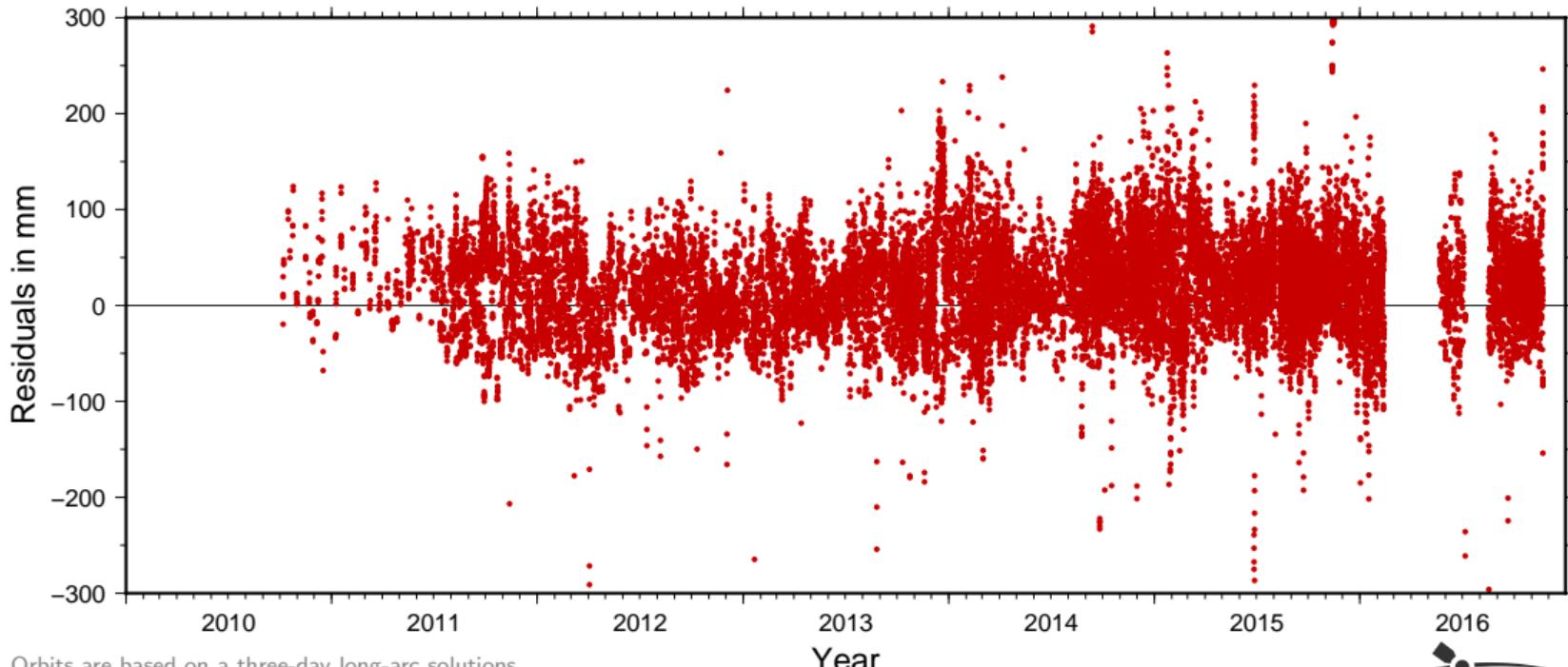
Applying the estimated satellite antenna offsets

SLR residuals for satellite SVN 736 (R09/R16)



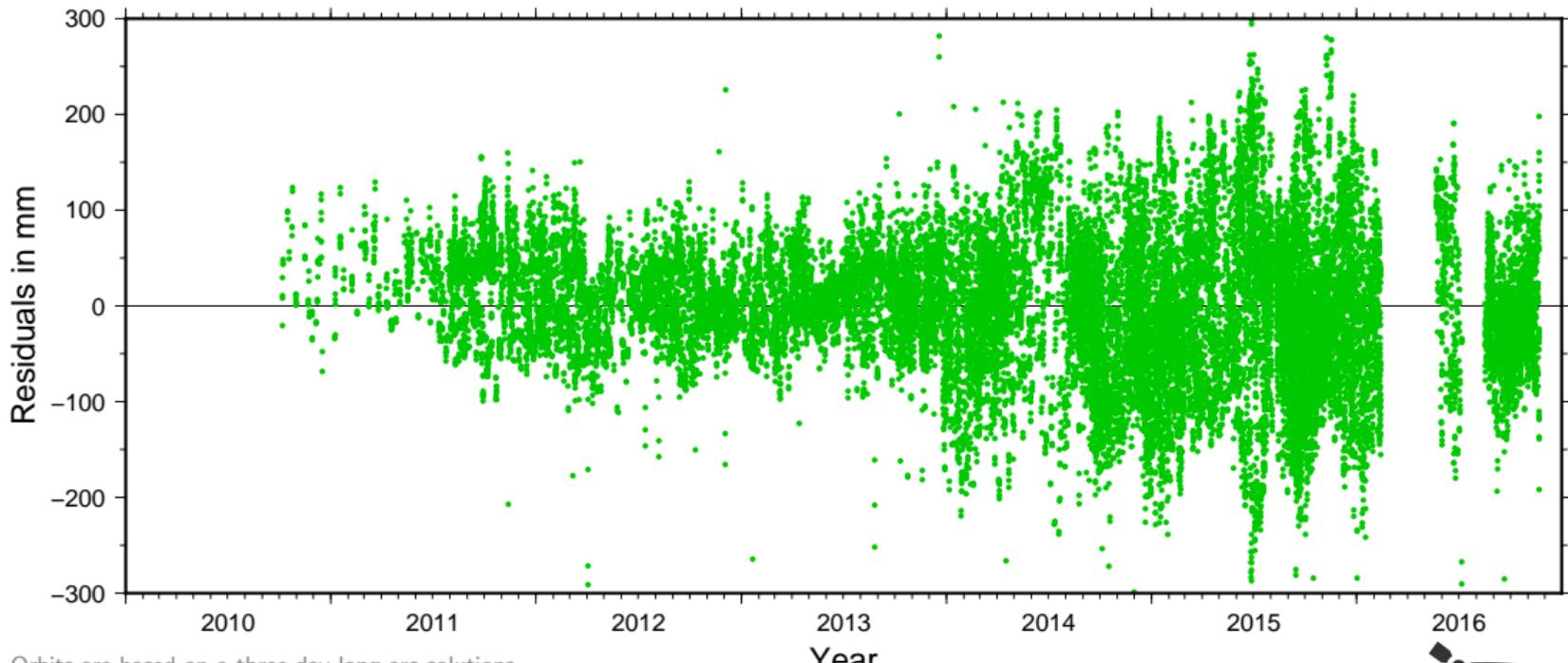
Applying the estimated satellite antenna offsets

SLR residuals for satellite SVN 737 (R12)



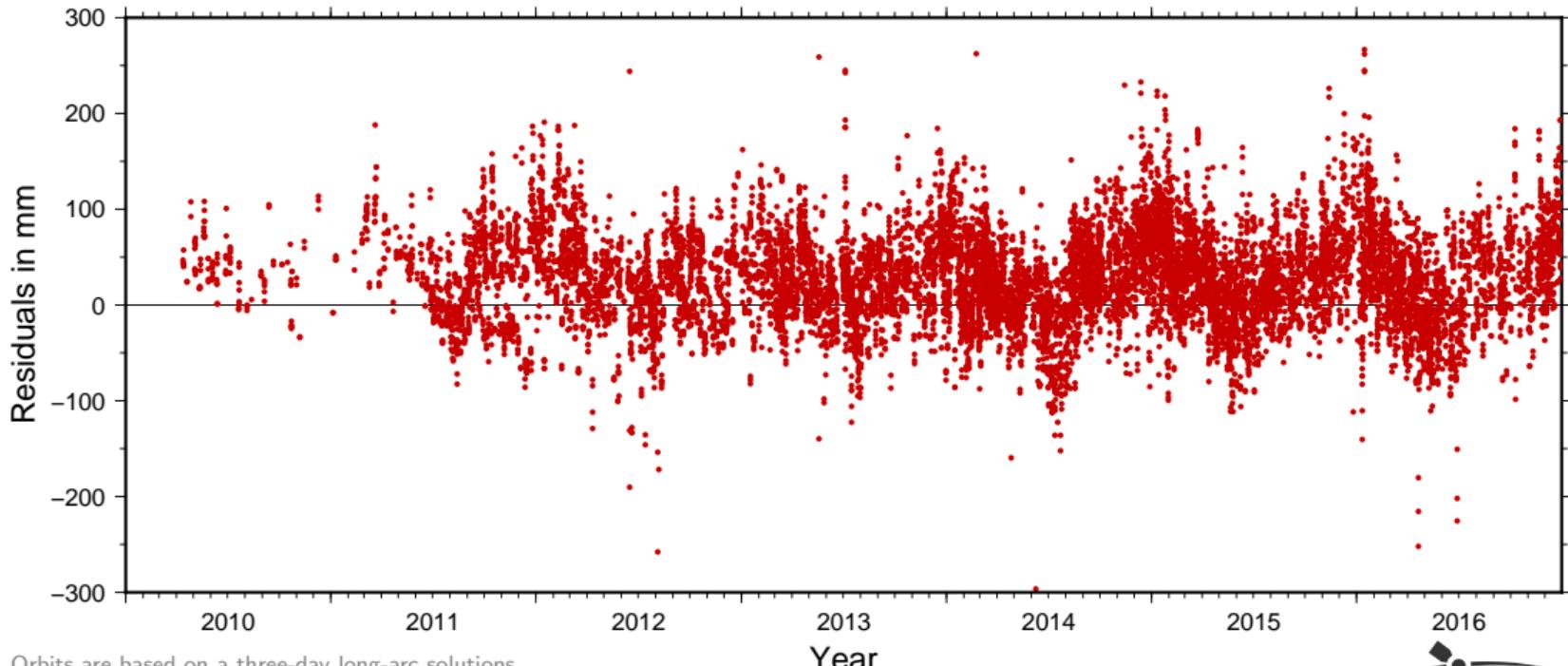
Applying the estimated satellite antenna offsets

SLR residuals for satellite SVN 737 (R12)



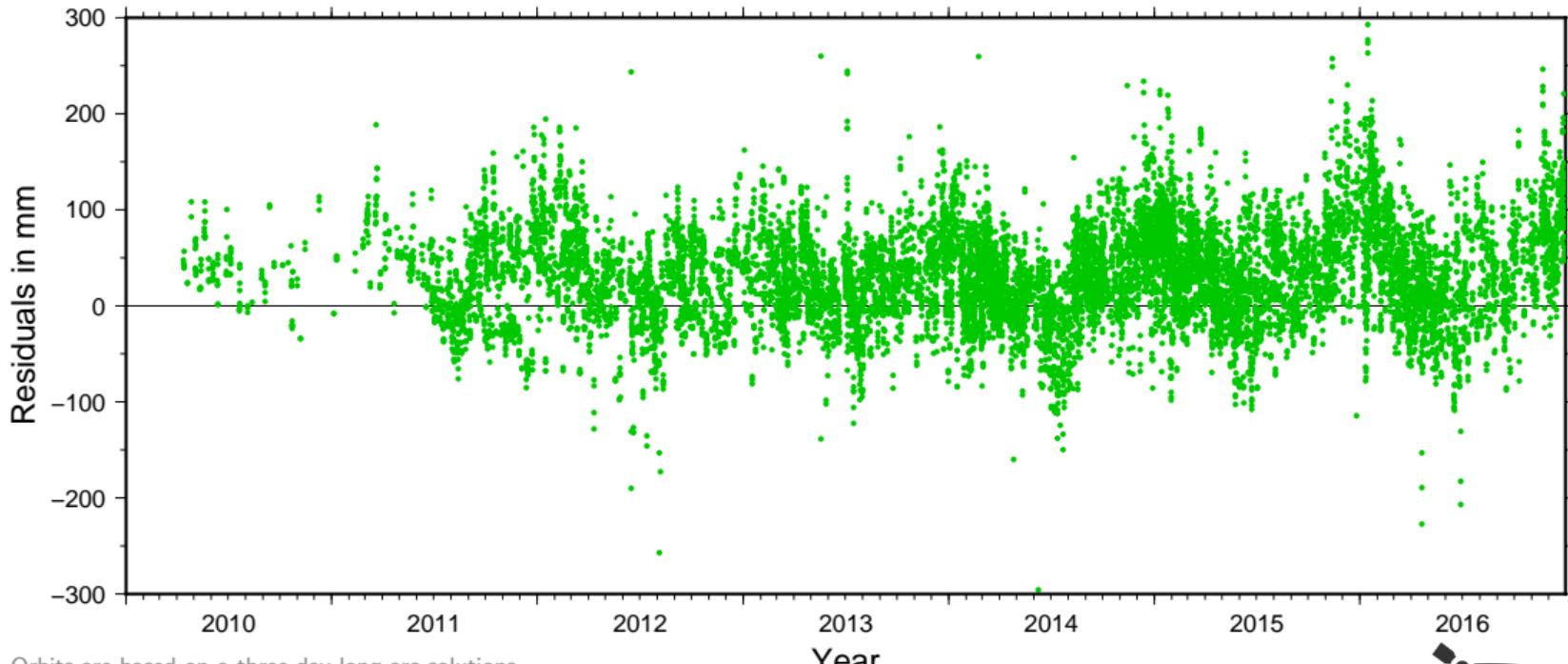
Applying the estimated satellite antenna offsets

SLR residuals for satellite SVN 735 (R05)



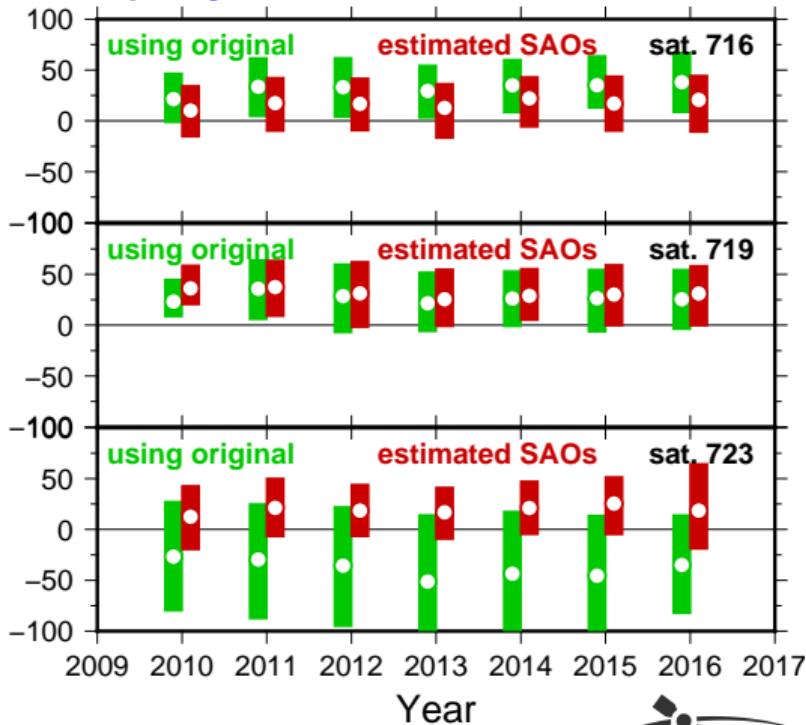
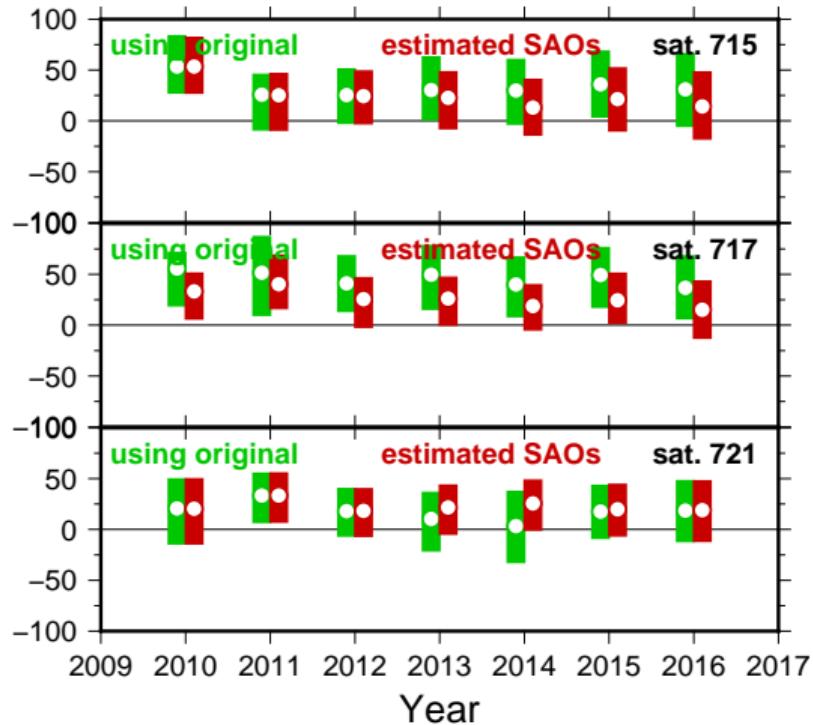
Applying the estimated satellite antenna offsets

SLR residuals for satellite SVN 735 (R05)



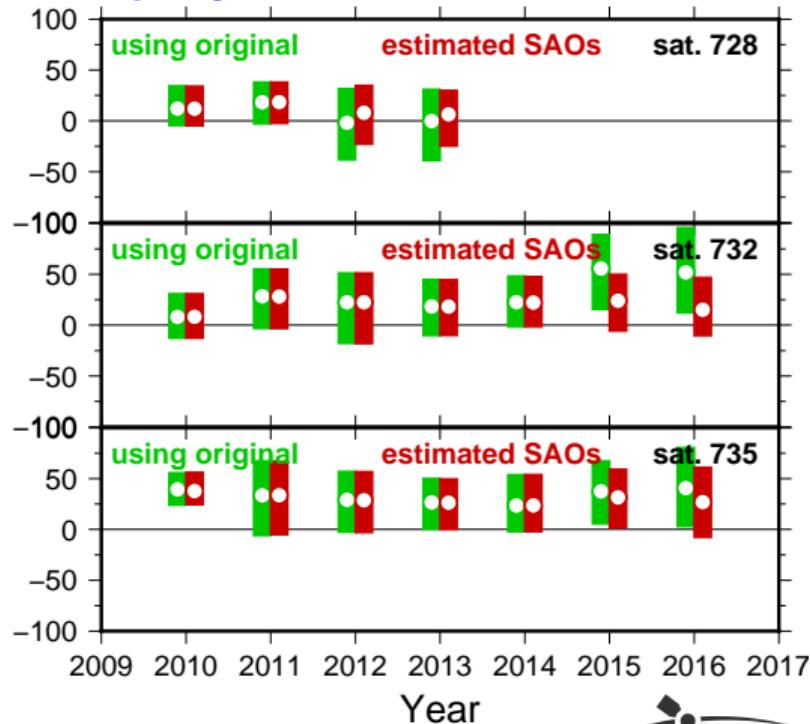
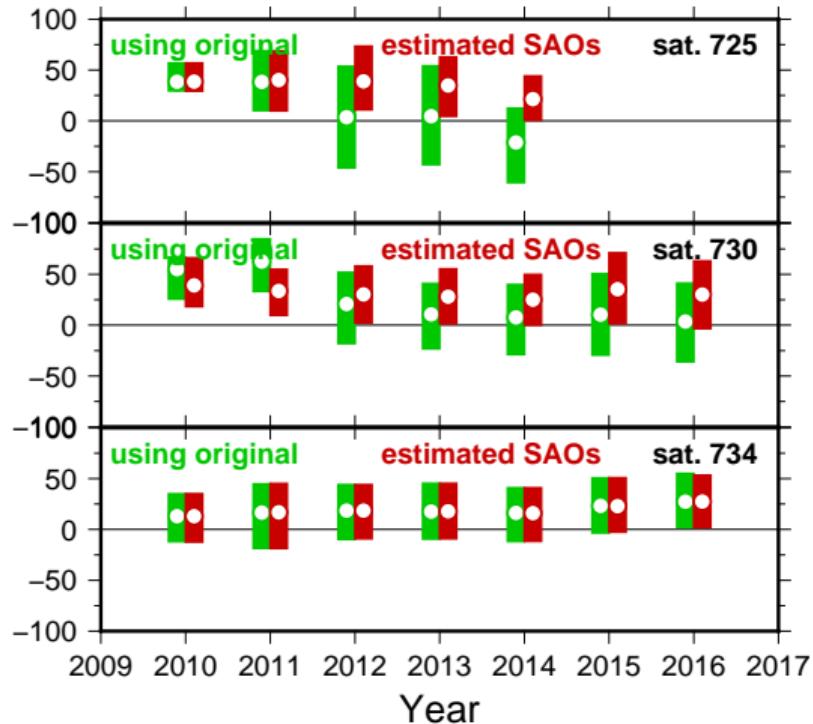
Applying the estimated satellite antenna offsets

Quantile 25%, 50%, and 75% of SLR residuals per year in mm



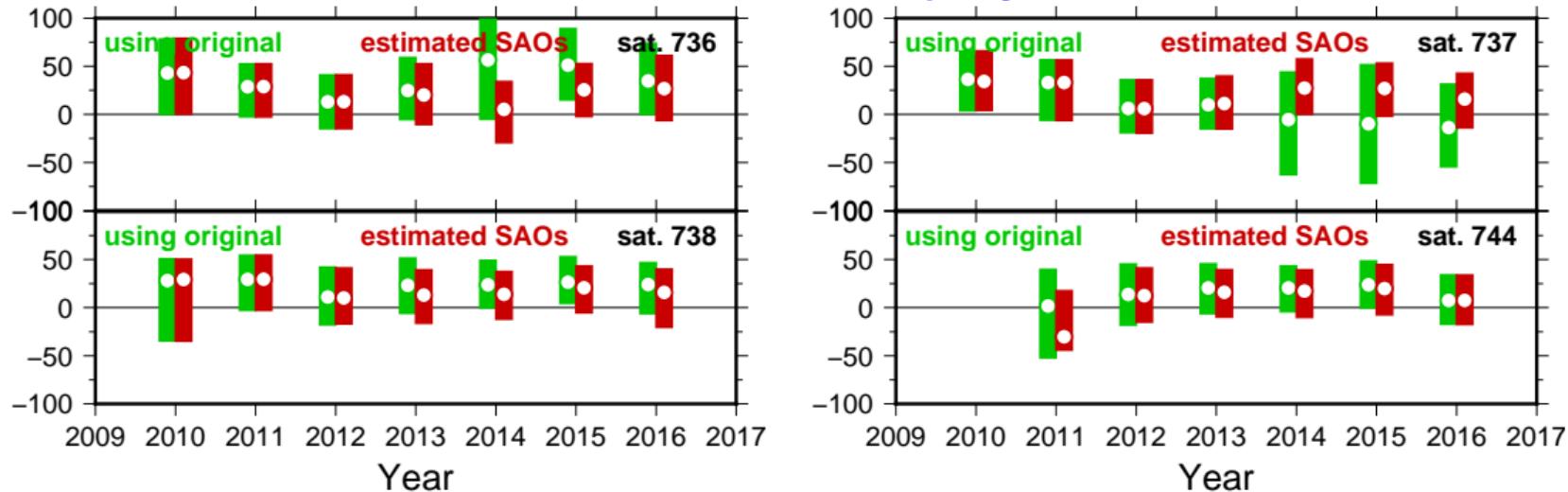
Applying the estimated satellite antenna offsets

Quantile 25%, 50%, and 75% of SLR residuals per year in mm



Applying the estimated satellite antenna offsets

Quantile 25%, 50%, and 75% of SLR residuals per year in mm



Orbits are based on a three-day long-arc solutions.

List of estimated satellite antenna offsets

Satellite		from	to	ΔX	ΔY	SAO-X	SAO-Y	Satellite type
701	R06	2008 04 27 00 00 00	2009 09 13 23 59 59	-0.1240	0.0037	-0.6691	0.0037	GLONASS-M
713	R24	2005 12 25 00 00 00	2010 02 28 23 59 59	-0.0507	-0.0412	-0.5957	-0.0412	GLONASS-M
714	R23	2006 02 28 00 00 00	2010 09 30 23 59 59	0.1507	-0.0586	-0.3943	-0.0586	GLONASS-M
714	R17	2010 12 16 00 00 00	2011 02 23 23 59 59	0.1507	-0.0586	-0.3943	-0.0586	GLONASS-M
715	R14	2011 10 02 00 00 00	2013 03 06 23 59 59	0.0016	-0.0772	-0.5434	-0.0772	GLONASS-M
715	R14	2013 03 07 00 00 00		0.0319	-0.1560	-0.5131	-0.1560	GLONASS-M
716	R15	2006 12 25 00 00 00		0.0387	0.0479	-0.5063	0.0479	GLONASS-M
717	R10	2006 12 25 00 00 00		0.0488	-0.0127	-0.4962	-0.0127	GLONASS-M
718	R17	2007 10 26 00 00 00	2010 12 15 23 59 59	0.0454	-0.0505	-0.4996	-0.0505	GLONASS-M
719	R20	2007 10 26 00 00 00	2011 03 05 23 59 59	-0.0660	0.0504	-0.6110	0.0504	GLONASS-M
719	R20	2011 03 06 00 00 00		-0.0128	0.1329	-0.5578	0.1329	GLONASS-M
721	R13	2013 10 20 00 00 00	2015 01 17 23 59 59	-0.0533	0.0712	-0.5983	0.0712	GLONASS-M
722	R09	2007 12 25 00 00 00	2010 09 30 23 59 59	-0.0354	-0.0144	-0.5804	-0.0144	GLONASS-M
723	R11	2007 12 25 00 00 00	2010 07 17 23 59 59	-0.0550	0.0049	-0.6000	0.0049	GLONASS-M
723	R11	2010 07 18 00 00 00	2016 03 02 23 59 59	-0.1222	0.0457	-0.6672	0.0457	GLONASS-M
725	R21	2011 11 06 00 00 00	2014 07 31 23 59 59	-0.1002	0.0144	-0.6452	0.0144	GLONASS-M
726	R22	2008 09 25 00 00 00	2010 02 28 23 59 59	-0.0343	-0.0050	-0.5793	-0.0050	GLONASS-M
728	R02	2012 05 06 00 00 00	2013 06 29 23 59 59	-0.0523	-0.0077	-0.5973	-0.0077	GLONASS-M
730	R01	2009 12 14 00 00 00	2010 12 18 23 59 59	0.0396	0.0073	-0.5054	0.0073	GLONASS-M
730	R01	2010 12 19 00 00 00	2012 07 14 23 59 59	0.0688	0.0121	-0.4762	0.0121	GLONASS-M

List of estimated satellite antenna offsets

Satellite		from	to	ΔX	ΔY	SAO-X	SAO-Y	Satellite type
730	R01	2012 07 15 00 00 00		-0.0694	0.0184	-0.6144	0.0184	GLONASS-M
732	R23	2015 02 01 00 00 00		0.0753	-0.0130	-0.4697	-0.0131	GLONASS-M
734	R05	2015 02 01 00 00 00		-0.0009	-0.1437	-0.5459	-0.1437	GLONASS-M
735	R24	2015 04 12 00 00 00		0.0329	0.1116	-0.5121	0.1116	GLONASS-M
736	R09	2013 12 08 00 00 00	2015 03 07 23 59 59	0.1589	-0.0166	-0.3861	-0.0166	GLONASS-M
736	R09	2015 03 08 00 00 00	2016 02 12 23 59 59	0.0554	-0.1265	-0.4896	-0.1265	GLONASS-M
736	R16	2016 03 07 00 00 00		0.0192	-0.1335	-0.5258	-0.1335	GLONASS-M
737	R12	2013 12 08 00 00 00	2015 12 26 23 59 59	-0.1254	-0.0149	-0.6704	-0.0149	GLONASS-M
737	R12	2015 12 27 00 00 00	2016 11 20 23 59 59	-0.0814	0.0252	-0.6264	0.0252	GLONASS-M
738	R16	2012 12 16 00 00 00	2016 02 13 23 59 59	0.0434	-0.0545	-0.5016	-0.0545	GLONASS-M
744	R03	2011 12 01 00 00 00	2015 11 07 23 59 59	0.0285	-0.0440	-0.5165	-0.0440	GLONASS-M
779	R01	1999 01 01 00 00 00	2002 07 08 23 59 59	0.0936	-0.0116	0.0936	-0.0116	GLONASS
783	R18	2000 10 13 00 00 00	2004 06 26 23 59 59	-0.0600	0.0330	-0.0600	0.0330	GLONASS
783	R18	2004 06 27 00 00 00	2007 05 24 23 59 59	-0.0914	0.1064	-0.0914	0.1064	GLONASS
788	R24	2003 09 07 00 00 00	2005 12 24 23 59 59	-0.0345	0.0698	-0.0345	0.0698	GLONASS
789	R03	2001 12 01 00 00 00	2008 12 24 23 59 59	-0.0149	0.0308	-0.0149	0.0308	GLONASS
791	R22	2002 12 25 00 00 00	2007 10 25 23 59 59	-0.0247	-0.0482	-0.0247	-0.0482	GLONASS
792	R21	2006 05 21 00 00 00	2008 09 24 23 59 59	-0.0626	0.0083	-0.0626	0.0083	GLONASS
796	R01	2004 12 26 00 00 00	2009 12 13 23 59 59	-0.0352	-0.0035	-0.0352	-0.0035	GLONASS
798	R19	2005 12 25 00 00 00	2007 10 25 23 59 59	-0.0675	0.0018	-0.0675	0.0018	GLONASS

Available as paper

Discussion and summary

What could be the reason at the spacecraft?

Shift of the center of mass:

If the satellite has roughly a mass of 1500 kg, 150 kg need to be shifted by 1 m in order to generate a COM shift of 10 cm.



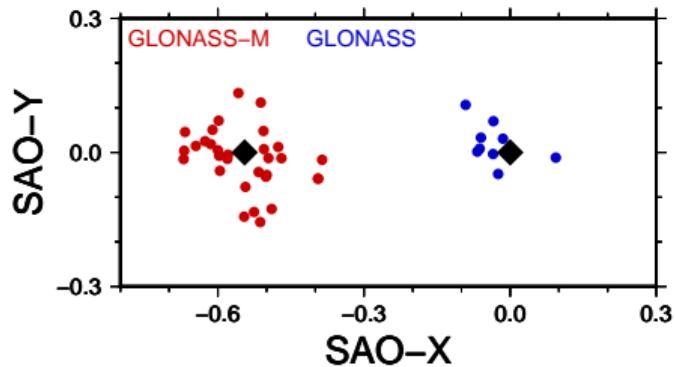
<http://spaceflight101.com/spacecraft/glonass-m/>

Discussion and summary

What could be the reason at the spacecraft?

Issue with satellite antenna:

Not likely because SAO-Z is not affected in most cases and the SAO-X/Y estimates do not show a pattern



<http://spaceflight101.com/spacecraft/glonass-m/>

Discussion and summary

What could be the reason at the spacecraft?

Satellite attitude misorientation:

The satellite plane with the navigation antenna and the SLR reflector is about 2 m away from the center of mass.

A shift of 10 to 15 cm results in a tilt of the 3 to 4 degree of the satellite body.



<http://spaceflight101.com/spacecraft/glonass-m/>

Discussion and summary

What could be the reason at the spacecraft?

- Shift of the center of mass:

If the satellite has roughly a mass of 1500 kg, 150 kg need to be shifted by 1 m in order to generate a COM shift of 10 cm.

- Issue with satellite antenna:

Not likely because SAO-Z is not affected in most cases and the SAO-X/Y estimates do not show a pattern

- Satellite attitude misorientation:

The satellite plane with the navigation antenna and the SLR reflector is about 2 m away from the center of mass.

A shift of 10 to 15 cm results in a tilt of the 3 to 4 degree of the satellite body.

Discussion and summary

What could be the reason at the spacecraft?

- Shift of the center of mass:

If the satellite has roughly a mass of 1500 kg, 150 kg need to be shifted by 1 m in order to generate a COM shift of 10 cm.

- Issue with satellite antenna:

Not likely because SAO-Z is not affected in most cases and the SAO-X/Y estimates do not show a pattern

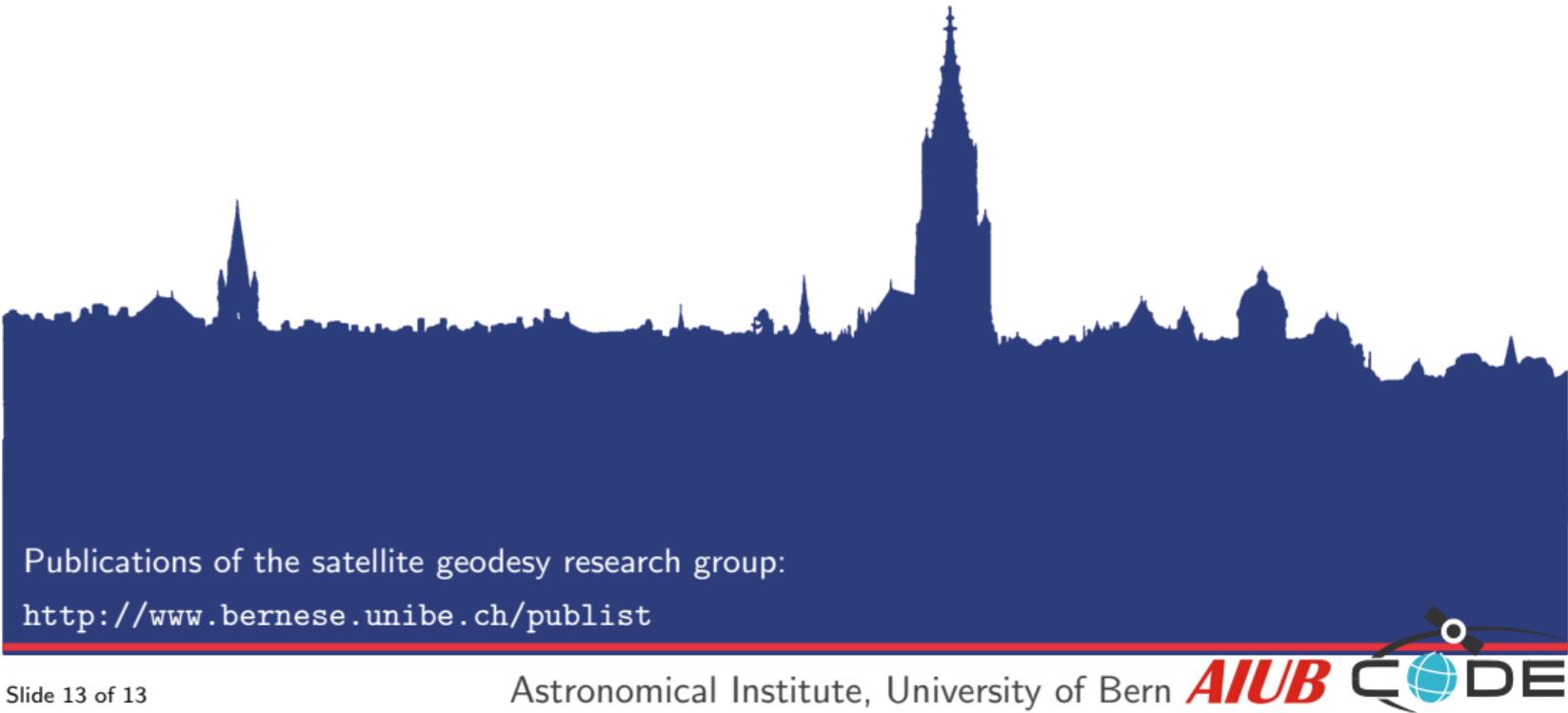
- Satellite attitude misorientation:

The satellite plane with the navigation antenna and the SLR reflector is about 2 m away from the center of mass.

A shift of 10 to 15 cm results in a tilt of the 3 to 4 degree of the satellite body.

The usage of the estimated SAOs obviously helps to reduce the SLR residuals and should be considered for repro3 after verification.

THANK YOU for your attention



Publications of the satellite geodesy research group:

<http://www.bernese.unibe.ch/publist>