DTRF2013: Results of the analysis and impact of the contribution of the International DORIS Service

Manuela Seitz, Detlef Angermann, Mathis Bloßfeld

Deutsches Geodätisches Forschungsinstitut (DGFI), Munich, Germany

e-mail: seitz@dgfi.badw.de





Motivation

Many model improvements for DORIS

Infrastructure

- Development of space and ground infrastructure
- More data collected from DGXX receiver (on Jason-2 first) seven stations observed in parallel

Modelling: satellites

- Physical models of satellites
- Improved solar radiation pressure modelling
- Improved air drag parameterization
- Gravity field: EIGEN-6S2 which includes annual variations

Modelling: station antennae

- Frequency offset considered (difference between actual admitted frequency and the nominal value)
- antenna phase center corrections

Willis, P.; Lemoine, F.G.; Moreaux, G.; Soudarin, L.; Ferrage, P.; Ries, J.; Otten, M.; Saunier, J.; Noll, C.; Biancale, R.; Luzum, B., in press. The International DORIS Service (IDS) - Recent developments in preparation for ITRF2013, IAG SYMPOSIA SERIES, 143



Input data and parameterization (I)

- Input data
 - SINEX files between 1993.0 and 2014.0
 - Weekly solutions (minimum constraints, not booked in SINEX → cannot be removed; need to introduce 7 similarity transformation parameters)





Input data and parameterization (I)

- Input data
 - SINEX files between 1993.0 and 2014.0
 - Weekly solutions (minimum constraints, not booked in SINEX → cannot be removed; need to introduce 7 similarity transformation parameters)



Satellite constellations (changes might have an effect on many time series)





Input data and parameterization (I)

- Input data
 - SINEX files between 1993.0 and 2014.0
 - Weekly solutions (minimum constraints, not booked in SINEX → cannot be removed; need to introduce 7 similarity transformation parameters)



Satellite constellations (changes might have an effect on many time series)



Input data and parameterization (II)

Input data



- 6 different Analysis Centers (ACs) using 5 different software packages

6

Input data and parameterization (II)

Input data



- 6 different Analysis Centers (ACs) using 5 different software packages

- Weekly SINEX files contain
 - 3D station coordinates at mid-week epoch
 - Terrestrial pole coordinates as offsets at 12h epochs (7 per week)
- Up to now, four iterations with IDS Combination Center, last iteration is expected for mid of November



CGE

Combination strategy at DGFI

□ Combination at DGFI is performed on normal equation (NEQ) level



Changes w.r.t. DTRF2008 processing:

- Correction for non-tidal atmospheric
 loading (NT-ATML) at NEQ level
 using an unique model provided by
 GGFC
- A posteriori estimation of annual/semi-annual signal of station position time series

Picture taken from Seitz M., Angermann D., Bloßfeld M., Drewes H., Gerstl M.: **The 2008 DGFI Realization of the ITRS: DTRF2008**. Journal of Geodesy, Volume 86, Issue 12, pp 1097-1123, doi: 10.1007/s00190-012-0567-2



Stochastic model



Solution of NEQ pseudo-observations are necessary

> Solution TRF+EOP

Solution of combined system

$$\widehat{x} = N^{-1}y$$

$$\sigma^2 = (\hat{\boldsymbol{v}}^T \boldsymbol{P} \hat{\boldsymbol{v}}) / (n - u) \text{ with } \boldsymbol{v}^T \boldsymbol{P} \boldsymbol{v} = \boldsymbol{b}^T \boldsymbol{P} \boldsymbol{b} - \hat{\boldsymbol{x}}^T \boldsymbol{b}$$

$$C_{\widehat{x}\,\widehat{x}}=\,\sigma^2 N^{-1}$$

with $C_{\hat{x}\hat{x}}$ is the variance-covariance matrix of the estimated variables.

DGFI

IDS Workshop 2014, Konstanz, Germany

Stochastic model



Analysis of DORIS input data





- □ Histogram of length of station time series (many short-terms?)
 - 149 stations in total (DTRF2008: 136)
 - 182 solution numbers \rightarrow 33 jumps (DTRF2008: 48)
 - 35% of stations contain less than 3.5 years of data (25% less than 2.5)

→ Estimation in DTRF2013? Final decision after a detailed analysis of the remaining signals in station position time series (correcting for NT-ATML may allow shorter length of time series (<2.5 years?)).



- □ Number of stations vs. DTRF2008
 - Three new stations
 - Replacement of all Alcatel antennae with Starec generation (Willis et al., 2014)



□ Number of discontinuities; Which of DTRF2008 can be removed?

1	/DGFI4/work/seitz/ITRF2013/0_input/misc/IDS_jumps_ITRF2008		✓ <u>B</u> rowse			GFI4/work/seitz/ITI	RF2013/0_input/mi	sc/IDS_jumps_ITRF2013_Mathis	
1	ADEA 91501S001 -647.0 0A02 # Earthquake 8.1 Mw	98:084 2			A	DEA 915015001	-647.0 0A02	# Earthquake 8.1 Mw	98:084 2
1n	AMTB 914015003 2153.0 0A02 # Antenna offset	05:327 1		→	← C	ADB 416095002	3119.0 OA02	# ?	08:198
11	COLA 23501S001 -1872.0 0A02 # Unknown	94:320 1			C	HAB 502075001	2139.0 0A02	# ?	05:313
	COLA 23501S001 547.0 0A03 # Earthquake	01:182 1		+	C	DLA 235015001	-1872.0 0A02	# Unknown	94:320 1
	DIOA 12602S011 -1736.0 0A02 # unknown	05:092 3		-	E	/EB 21501S001	805.0 OA02	# Unknown	02:075 1
	DJIB 39901S003 2400.0 0A02 # data gaps	06:209 2			F.	AIB 40408S005	1037.0 0A02	# Earthquake	02:307 1
	EVEB 21501S001 805.0 0A02 # Unknown	02:075 1			E/	AIB 40408S005	1128.0 OA03	# Postseismic	03:033 2
	FAIA 40408S004 -1462.0 0A02 # unknown	96:001 3		+	E.	AIB 40408S005	1310.0 OA04	# Postseismic	03:215 2
	FAIB 40408S005 1037.0 0A02 # Earthquake	02:307 1			E.	AIB 40408S005	2191.0 OA05	# Postseismic	06:001 2
	FAIB 40408S005 1128.0 0A03 # Postseismic	03:033 2			G	DMB 40405S037	1603.0 OA03	# Oscillator problem	04:143 1
11.	FAIB 40408S005 1310.0 0A04 # Postseismic	03:215 2			← G	REB 40451S176	2216.0 0A02	# ?	06:025
	FAIB 40408S005 2191.0 0A05 # Postseismic	06:001 2			H	ELB 30606S003	31.0 OA02	# Antenna tilt	00:031 2
	GAVB 12618S001 2276.0 0A02 # Unknown	06:085 2		→///	ΨH	MB 30606S004	3196.0 0A02	# ?	08:275
	GOMB 40405S037 -77.0 0A02 # Hector Mine Earthq.	99:289 2			KI	ESB 912015004	1496.0 OAO2	# Unknown	04:036 2
	GOMB 40405S037 1603.0 0A03 # Oscillator problem	04:143 1			← KI	RUB 973015004	1957.0 0A02	# ?	05:131
	HELB 30606S003 31.0 0A02 # Antenna tilt	00:031 2			M	AHB 398015005	3070.0 0A02	# ?	08:149
	HELB 30606S003 943.0 0A03 # After gap	02:213 2		\rightarrow	/ M	ARB 30313S002	899.0 OAO2	# Unknown	02:169 2
	KESB 91201S004 1496.0 0A02 # Unknown	04:036 2			M	ATB 30313S003	2191.0 OAO2	# Antenna offset	05:365 2
	KRAB 12349S001 -485.0 0A02 # Unknown	98:246 2		→ /	R	EUB 97401S002	3131.0 OAO2	# Beacon event	08:210 2
	KRAB 12349S001 2070.0 0A03 # Earthquake	05:244 2			// RI	EZB 10202S003	1897.0 OAO2	# Unknown	05:072 1
-	MANB 22006S002 1652 0 0A02 # Unknown	04:192 2			R	EZB 10202S003	3076.0 OA03	# Earthquake	08:157 2
	MANB 22006S002 2018.0 0A03 # Unknown	05:184 2			R	CPB 41507S005	1980.0 OA02	# Unknown	05:154 1
	MARB 30313S002 899.0 0A02 # Unknown	02:169 2			R	DTA 66007S001	743.0 0A02	# Unknown	02:013 2
-11	MATB 30313S003 2191.0 0A02 # Antenna offset	05:365 2			S	AKA 12329S001	-1909.0 0A02	# Unknown	94:283 1
	MATB 30313S003 2504.0 0A03 # Antenna offset	06:313 3		→ //	S	AKA 123295001	-371.0 0A03	# Unknown	98:360 1
	MATB 303135003 2690.0 0A04 # Antenna offset	07:134 2			← S	ANB 417055009	2153.0 0A02	# 1	05:327
	MORB 51001S002 1249.0 0A02 # Equipment problem	03:152 2			S	ANB 417055009	3/49.0 0A03	# (10:097
	MORB 510015002 1694.0 0A03 # Equipment problem	04:234 1			S	ANB 417055009	4001.0 0A04	# (10:349
	REUB 974015002 3131.0 0A02 # Beacon event	08:210 2		11		THE 660065003	4575.0 0A02	# f	12:193
	RETB 122025002 169.0 0A02 # Earthquake	00:169 2		→		JB 401015002	167 0 0A02	# Unknown	02:230 3
	REZB 102025003 1097.0 0A02 # Unknown	05:072 1			/ #	TR 206045001	-167.0 0A02	# Unknown	99:190 2
	REZB 102025005 5076.0 0A05 # Earthquake	06:15/ 2				ALD 306045002	1807 0 0A02	# often data gan	04:215 1
11	POTA 660075003 742 0 0402 # Unknown	03:134 1				-JB 1031/3005	1007.0 0402	# aiter uata gap	04:547
	SAKA 122295001 -1909 0 0A02 # Unknown	02.013 2		1+	//				
	SAKA 123295001 -1903.0 0A02 # Unknown	98:360 1					_		
	SAKA 123295001 1363 0 0404 # Unknown	03:268 2		<u>_ </u>					
	SANB 417055009 1242 0 0402 # Unknown	03.147 1		~///					
	SPTB 103175004 805 0 0402 # Unknown	02:075 2						-	
	SPTB 103175004 1200 0 0403 # Unknown	03:205 3						Reduction	
	STJB 40101S002 960.0 0A02 # unknown	02:230 3							
	TRIA 306045001 -167.0 0A02 # Unknown	99:198 2							
	TRIB 30604S002 1674.0 0A02 # Unknown	04:213 1		11			OT	necessarv	
	YASB 50107S011 1897.0 0A02 # Unknown	05:071 2		-			•		
	YASB 50107S011 2800.0 0A03 # Unknown	07:244 2		11			dice	continuition	
	METB 10503S015 701.0 0A02 # after data gap	01:336					0150	Johunulles	
	SPJB 10317S005 1807.0 0A02 # after data gap	04:347		7/					
	JIUB 21602S005 1891.0 0A02 # affer data gap	05:065		+					
100									



CGE

- □ Number of discontinuities; Which of DTRF2008 can be removed? → unify with IGN, JPL!
- □ e.g., Station AMTB (Amsterdam Islands)







Datum time series of IDS weekly (DTRF2008) vs. IDS multiyear (DTRF2008)



→ Correlation with solar cycle is still visible.



ĊGE





- Why is scatter of DTRF2013 IDS input higher than DTRF2008 IDS input?
- What cause higher STDs in DTRF2013 IDS input? Can the effect be just related to the more realistic stochastic model?



ĊGE



- GPS draconitics in x-pole; good agreement in y-pole
- Why are the GPS draconitics for the IDS DTRF2013 input higher than for the IDS DTRF2008 input?



ĊGE

DORIS multi-year solution

RMS of transformation \rightarrow Agreement of network geometries

- IDS multiyear (DTRF2013) w.r.t. DTRF2008: 7.9 mm (coord), 1.6 mm (vel)
- IDS multiyear (DTRF2008) w.r.t.
 - IDS multiyear (DTRF2008):

7.0 mm (coord), 1.5 mm (vel)

Histogram of transformation residuals



Summary & Outlook

- □ Many model improvements for DORIS since DTRF2008
- □ Realistic stochastic model due to the availability of stochastic values
- □ Annual signal in translation time series is reduced vs. DTRF2008
- □ Correlation of Tz with solar cycle still visible but with a slightly smaller amplitude
- Scale drift seen in DTRF2008 input data is removed but scale jump in 2012 needs to be further investigated. Correlation with HY-2A and Saral?
- Pole coordinates of DTRF2013 input show higher scatter and STDs than DTRF2008 input. Can the increased STD be explained by the more realistic stochastic model only?

Outlook

ĊGE

- □ Unification of discontinuity list with IGN and JPL
- □ Application of a posteriori NT-ATML correction at normal equation level
- □ Please keep in mind that another iteration will be provided by the IDS CC.



IDS Workshop 2014, Konstanz, Germany

Thank you very much for your attention! Many thanks to the IDS for providing the data!

DTRF2013: Results of the analysis and impact of the contribution of the International DORIS Service

Manuela Seitz, Detlef Angermann, Mathis Bloßfeld

Deutsches Geodätisches Forschungsinstitut (DGFI), Munich, Germany

e-mail: seitz@dgfi.badw.de

For more details on DTRF2013, please visit http://dgfi.badw.de/en/products/dtrf2013







