



Federal Agency for
Cartography and Geodesy



REFAG
THESSALONIKI- GREECE 2022



BKG

Wir geben Orientierung.



On the improvement of the consistency and the temporal regularity of combined ERP time series

Lisa Klemm (née Lengert), Daniela Thaller, Claudia Flohrer, Hendrik Hellmers, Anastasiia Giridiuk

Federal Agency for Cartography and Geodesy (BKG), Department Geodesy, Frankfurt am Main, Germany

Agenda

VLBI observation campaigns

VLBI ERP time series

Multi-day intra-technique combination of VLBI data

Constraining

First results

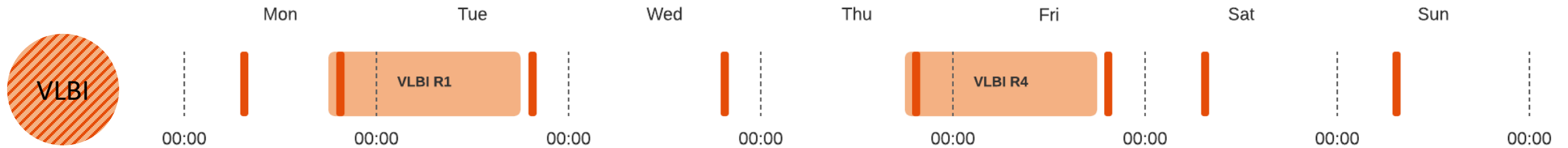
Current challenges

Multi-day inter-technique combination of GNSS, VLBI and SLR

Results

Outlook

VLBI observation campaigns

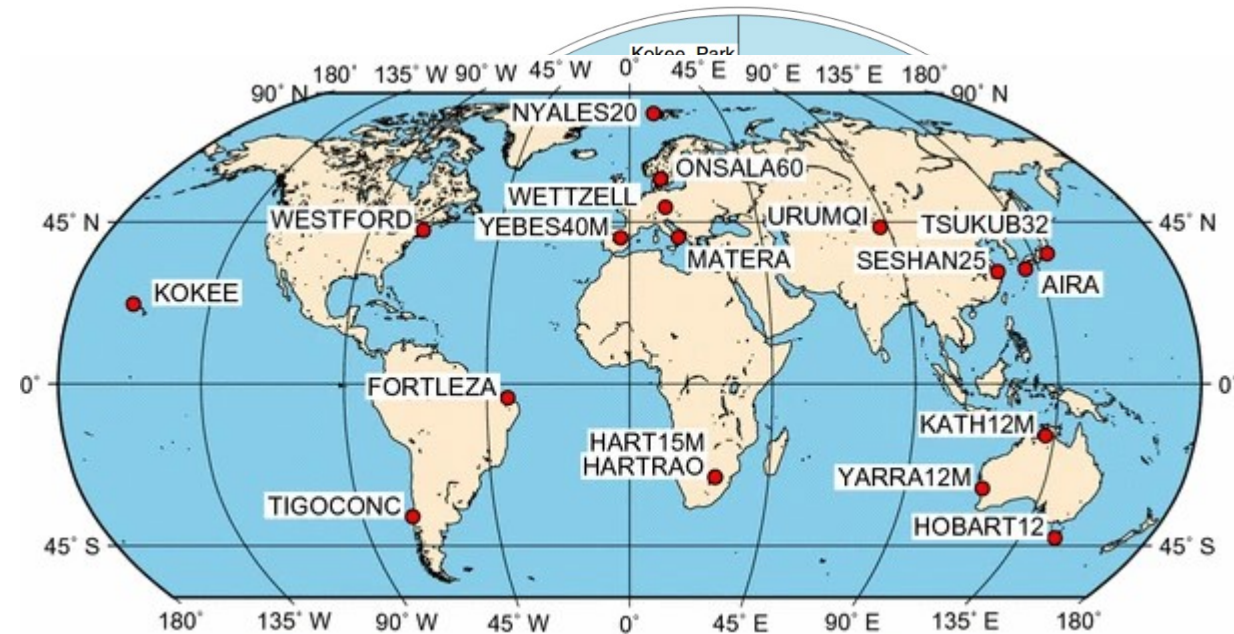


24 hour campaigns

- twice per week (R1/R4)
- global station network
- estimation of all five EOP
- Latency: approx. 14 days

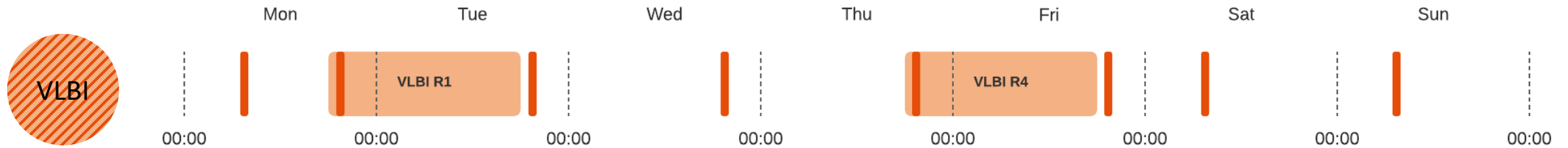
1 hour campaigns (INTENSIVE)

- at least once a day, not equidistant in time
- Station network of only 2-3 antennas
- estimation of dUT1
- Latency: approx. 1-2 days



[Kizpat et al. in Geodesy (2020) 84:929-957 doi:10.1007/s00094-020-00721-4]

VLBI EOP time series



Status Quo...

R1/R4

epoch [MJD]	xPo1 [as]	yPo1 [as]	dUT1 [s]
52282.22043	-0.1821652	0.3159690	-0.12416808
52285.27247	-0.1830762	0.3252117	-0.12586561
52289.20781	-0.1812679	0.3376474	-0.12606027
52292.27444	-0.1790933	0.3471553	-0.12668329
52297.20475	-0.1769668	0.3628123	-0.12941534
52299.26872	-0.1753894	0.3697257	-0.13039180

- + high accuracy
- no daily resolution
- no regular resolution

INT

MJD (days)	X-Wob apriori (")	Y-Wob apriori (")	UT1-UTC (s)
57757.791345	0.07906	0.26466	0.5863588
57758.801761	0.07707	0.26500	0.5847417
57761.333011	0.07305	0.26538	0.5808252
57763.792039	0.06943	0.26597	0.5775262
57764.697595	0.06768	0.26654	0.5764945

- high accuracy only within the observation period
- + daily resolution
- no regular resolution

Idea ...

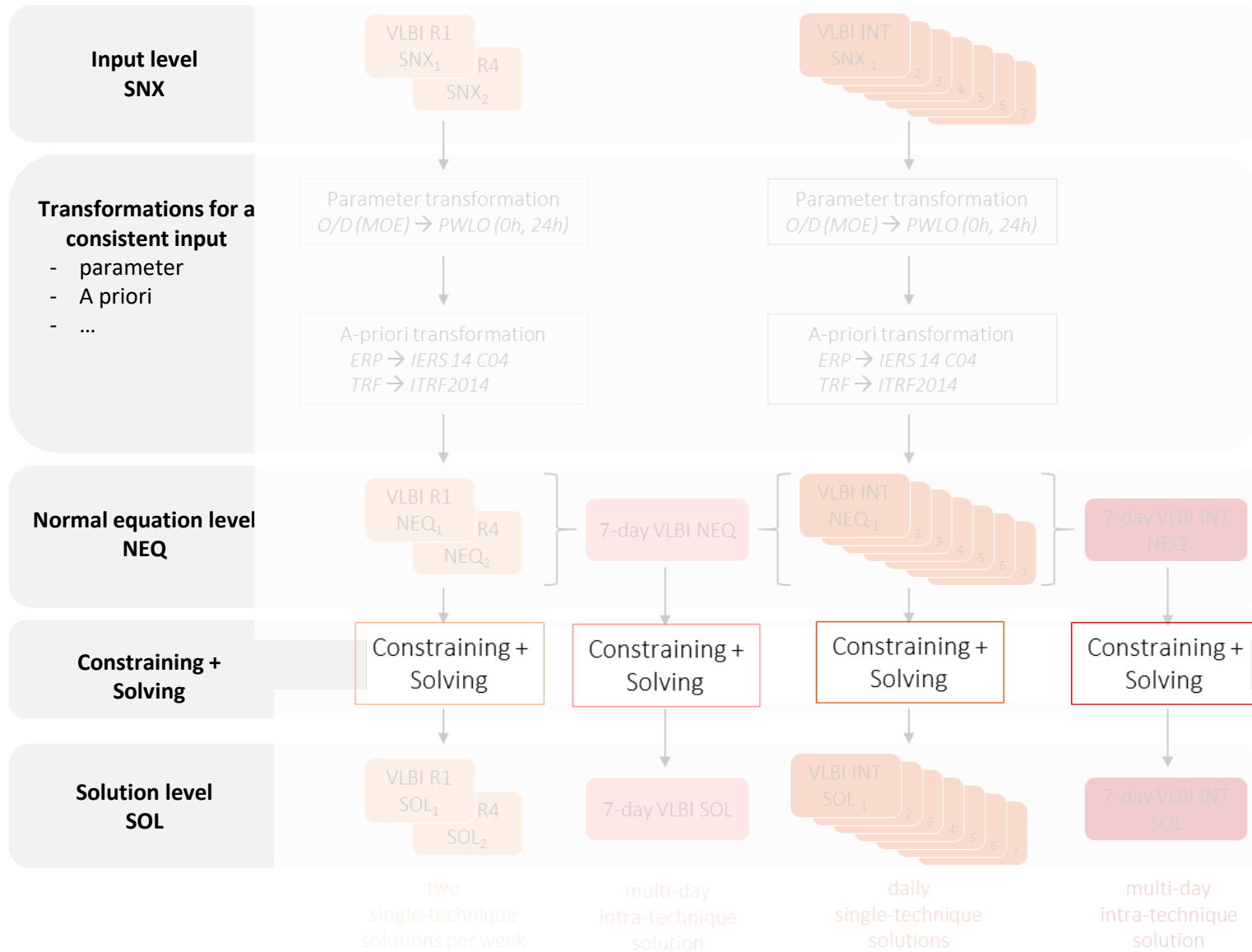
COMBI

epoch [mjd]	UT1-UTC p_est [ms]	d_est [ms]	p_sig [ms]
56837.00000	-301.50791	0.07719	0.000691
56838.00000	-301.86173	0.00367	0.000671
56839.00000	-302.23543	0.01727	0.000733
56840.00000	-302.69268	0.01322	0.000766
56841.00000	-303.23525	0.01565	0.000870

- + high accuracy
- + daily resolution
- + regular resolution

» ... easier comparability
» ... input for EOP prediction

Combination scheme



input for combination

SINEX from BKG IVS AC

combination at NEQ level

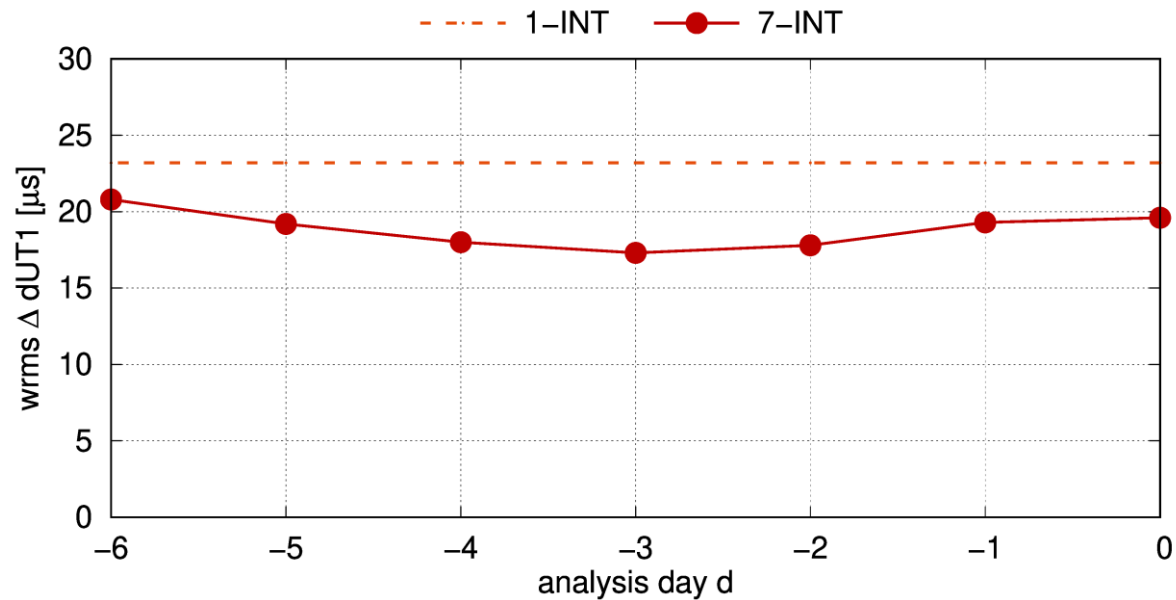
DOGS-CS software from DGFI TUM

Constraining – Overview



Parameter (explicit)		VLBI R1/R4	n-day VLBI	VLBI INT	n-day VLBI INT
	UT1-UTC (dUT1)	-	-	LOD fixed to IERS-14-C04	-
EOP	X-/Y-pole	-	R1/R4: (loose constraint) INT: fixed to IERS-14-C04	fixed to IERS-14-C04	fixed to IERS-14-C04
	nutaton	-	-	/	/
TRF		minimum constraints (NNR/NNT for core sites)	minimum constraints (NNR/NNT for core sites)	fixed to ITRF2014	fixed to ITRF2014
CRF		fixed to ICRF-3	fixed to ICRF-3	/	/

Validation epoch: **12:00 UTC**



Reference series: **IERS-Bulletin-A**

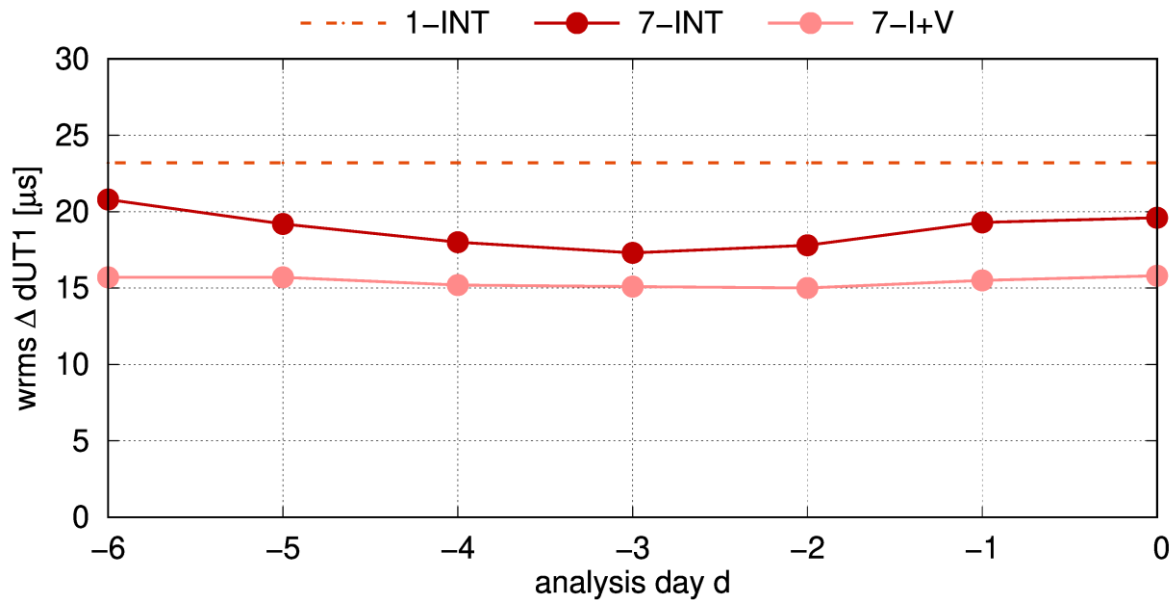
7-INT

7-day VLBI INT

- significant reduction of the WRMS
 - parabolic behavior of the WRMS
 - minimal values at the middle day
 - no constraining of LOD
 - accuracy less dependent of observation period
- **daily, regularly spaced dUT1 product**
- **latency of 1-2 days**

First results – Intra-technique combination of VLBI Intensive and R1/R4 data

Validation epoch: **12:00 UTC**



Reference series: **IERS-Bulletin-A**

7-day VLBI INT + R1/R4

- significant reduction of the WRMS
 - constant level of the WRMS
 - no constraining of LOD
 - no fixing of the station network
 - improved accuracies outside the observation period
- daily, regularly spaced dUT1 product
- latency: approx. 14 days

7-I+V

Current challenges – Datum definition

Parameter	VLBI R1/R4	n-VLBI	VLBI INT	n-VLBI INT
Station coordinates	minimum constraints → NNR/NNT for core sites	minimum constraints → NNR/NNT for core sites	fixed to ITRF2014	fixed to ITRF2014

Pre-condition:

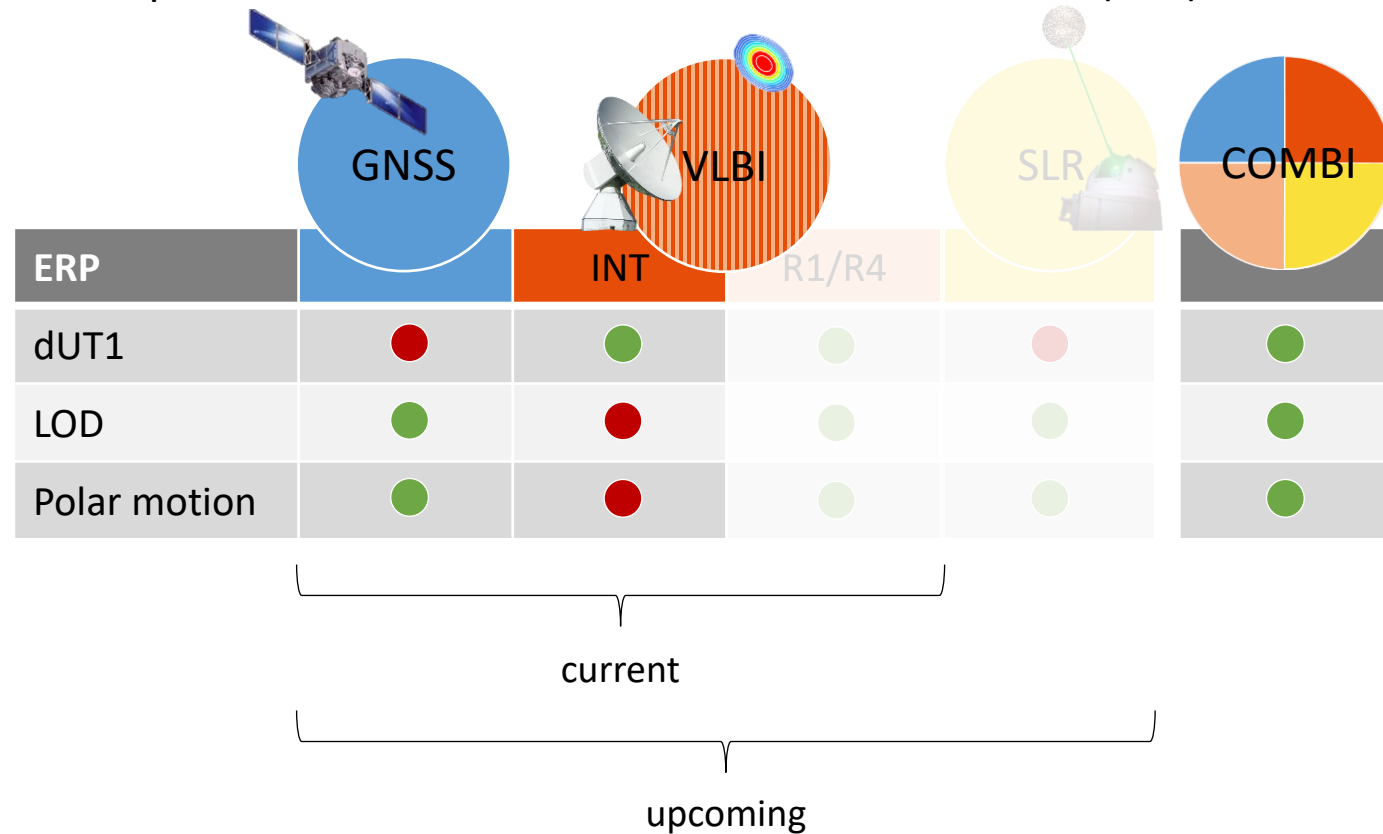
The antennas observing in the INT sessions must also be included in the station network of the 24-hour sessions!

- Station coordinates can be stacked and estimated
- usually the case, **but there are exceptions**
- Next step: systematic investigation and tuning of the datum definition

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
INT1	WETTZELL KOKEE	WETTZELL KOKEE	WETTZELL KOKEE	WETTZELL KOKEE	WETTZELL KOKEE	-	-
INT2	-	-	-	-	-	WETTZELL MK-VLBA	WETTZELL MK-VLBA
INT3	WETTZELL WETTZ13S NYALE13S NYALES20 SESHAN25	-	-	-	-	-	-
R1 / R4	WETTZ13N NYALE13S NYALES20 KOKEE HART15M MATERA NOTO ONSALA60 YARRA12M 7390	-	-	WETTZELL NYALE13S NYALES20 KOKEE BADARY HART15M YARRA12M ZELENCHK 7230 7377	-	-	-

Multi-technique combination of GNSS, VLBI and SLR data at NEQ level

Techniques' contributions to Earth Rotation Parameters (ERP)

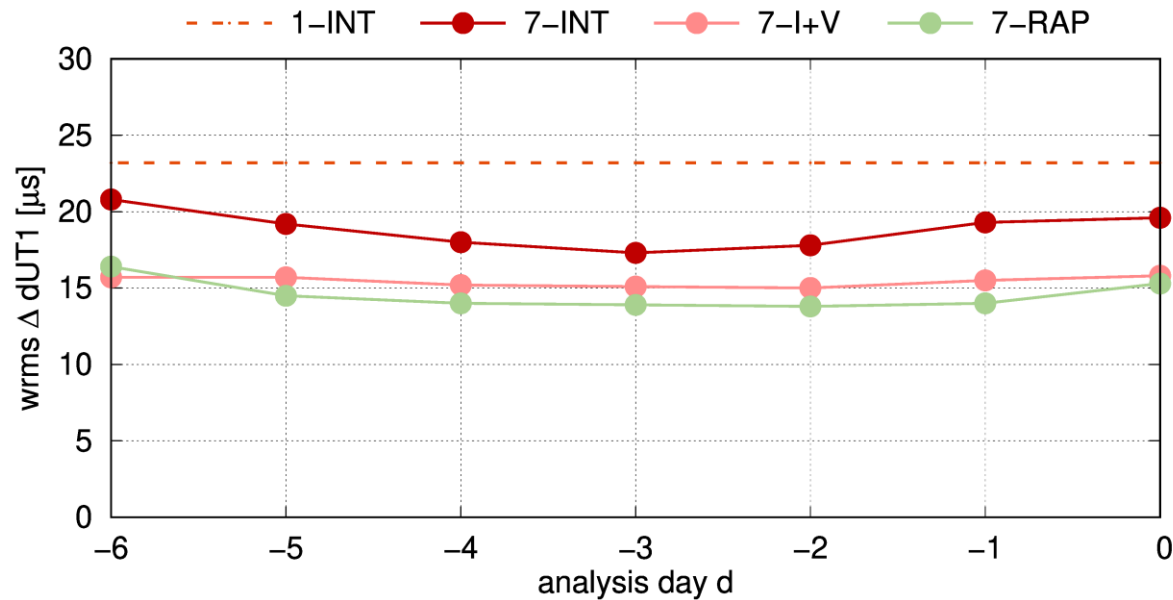


benefits of multi-technique combination

- + **GNSS + VLBI INT** daily resolution and shorter latency of a consistent set of all ERPs
- + stabilization of the ERPs by multi-day combination
- + stabilization through 24h **VLBI R1/R4**
- + stable contribution of LOD from **SLR**

Results – Multi-technique combination of GNSS and VLBI Intensive data

Validation epoch: **12:00 UTC**



Reference series: **IERS-Bulletin-A**



7-day GNSS + VLBI INT

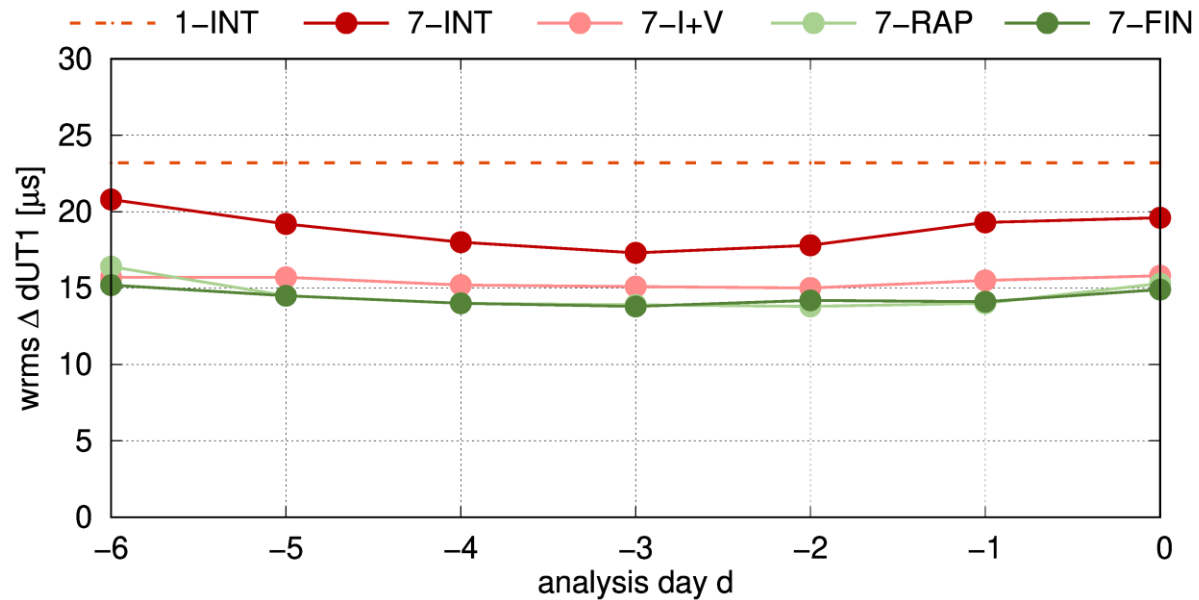
- significant reduction of the WRMS
- bridging of VLBI data gaps with GNSS data
- 1h-VLBI-INT-dUT1 + 24h-GNSS-LOD + 24h-GNSS-pole

→ daily, regularly spaced ERP product

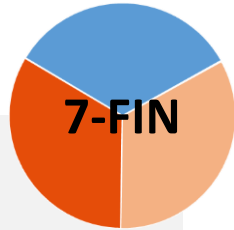
→ latency: 1-2 days

Results – Multi-technique combination of GNSS and VLBI data

Validation epoch: **12:00 UTC**



Reference series: **IERS-Bulletin-A**



7-day GNSS + VLBI INT + VLBI R1/R4

- almost constant level of the WRMS
- stabilization through 24h VLBI R1/R4 twice a week
- daily, regularly spaced **ERP** product
- latency: approx. 14 days

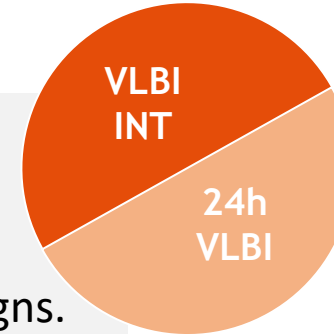
Next steps

VLBI intra-technique combination

Systematic investigations of the station networks.

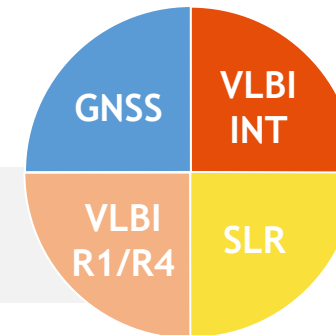
→ improvement of the datum definition

Extend the combination by adding further VLBI observation campaigns.



Multi-technique combination

Extend the combination by adding SLR data.



Development of an operational combined dUT1/ERP product at BKG.





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Thank you for your kind attention!

Bundesamt für Kartographie und Geodäsie
Organisationseinheit
Richard-Strauss-Allee 11
60598 Frankfurt am Main

Lisa Klemm
Lisa.Klemm@bkg.bund.de
www.bkg.bund.de
Phone +49 69 6333 – 449

Combination Scheme

