The impact of independent GNSS geocenter and scale information on four-technique reference frames

COSPAR

Jul 20, 2018

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Government sponsorship acknowledged.

Introduction

Goals
Utilize GNSS geocenter and scale estimates
Reduce frame build time to less than 15 minutes

Inputs
GNSS solutions from Haines et al.
DORIS solutions from the IDS
SLR solutions from the ILRS
VLBI solutions from the IVS
TIES

Independent GNSS geocenter and scale estimates
Haines et al., 2015, J. Geophys. Res. Solid Earth, 120, 5911–5939
Antenna calibrations from GRACE and TOPEX
Nine day arcs

Limit the number of parameters
Choose sites which are fit well by a linear model with breaks
Use a free-network approach without Helmert parameters
No seasonals, process noise, or eop

Combine DORIS

Span
1993 through 2014

Files
1140

Combine
netFit.py -i *.edit -o doris.gdcov -v 05JAN01 -b doris.breaks

CPU
4 minutes

Combine GNSS

Span
1997 through 2013

Files
818

Combine
netFit.py -i *.edit -o gps.gdcov -v 05JAN01 -b gps.breaks

CPU
2 minutes

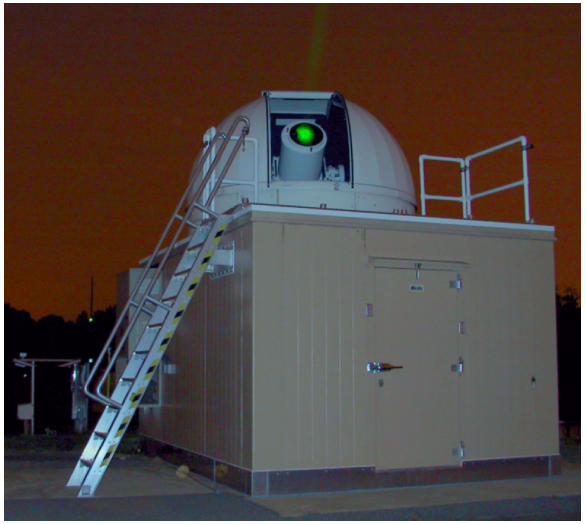
Combine SLR

Span
1983 through 2014

Files
1376

Combine
netFit.py -i *.edit -o slr.gdcov -v 05JAN01 -b slr.breaks

CPU
1 minute



Combine VLBI

Span
1979 through 2014

Files
5275

Combine
netFit.py -i *.edit -o vlbi.gdcov -v 05JAN01 -b vlbi.breaks

CPU
2 minutes

Build Frame

284 Sites + 80 Ties
DORIS 86
GPS 111
SLR 42
VLBI 45

Combine
netFit.py -i doris.project gps.project slr.project vlbi.project tie.project
-o frame.gdcov -v 2005-01-01 -b frame.break –m

Weights
Change geocenter and scale weights to create different frames

CPU
1 minute

Weighting Examples

Use VLBI scale and SLR geocenter

```
netProject.py -i doris.gdcov -o doris.project -r -t -s -u
netProject.py -i gps.gdcov -o gps.project -t -s -u
netProject.py -i slr.gdcov -o slr.project -r -s -u
netProject.py -i vlbi.gdcov -o vlbi.project -r -t -u
```

Use SLR scale and GNSS geocenter

```
netProject.py -i doris.gdcov -o doris.project -r -t -s -u
netProject.py -i gps.gdcov -o gps.project -s -u
netProject.py -i slr.gdcov -o slr.project -r -t -u
netProject.py -i vlbi.gdcov -o vlbi.project -r -t –s
```

Compare Frames to ITRF2014 on 01Jan05

VLBI Scale, SLR Geocenter

	TX	TY	TZ	S	RX	RY	RZ	
OFFSET	0.508	-0.192	-0.144	2.903	0.543	-0.053	-0.354	mm
OFFSET SIGMA	0.102	0.095	0.200	0.521	0.117	0.141	0.204	mm
RATE	-0.184	0.044	0.498	0.153	0.001	0.076	0.156	mm/yr
RATE SIGMA	0.013	0.012	0.027	0.036	0.018	0.021	0.026	mm/yr

SLR Scale, SLR Geocenter

	TX	TY	TZ	S	RX	RY	RZ	
OFFSET	0.508	-0.192	-0.144	-4.118	0.543	-0.053	-0.354	mm
OFFSET SIGMA	0.102	0.095	0.200	0.072	0.117	0.141	0.204	mm
RATE	-0.184	0.044	0.498	-0.057	0.001	0.076	0.156	mm/yr
RATE SIGMA	0.013	0.012	0.027	0.010	0.018	0.021	0.026	mm/yr

GNSS Scale, SLR Geocenter

	TX	TY	TZ	S	RX	RY	RZ	
OFFSET	0.508	-0.192	-0.144	3.417	0.544	-0.054	-0.354	mm
OFFSET SIGMA	0.102	0.095	0.200	0.402	0.117	0.141	0.204	mm
RATE	-0.184	0.044	0.498	0.243	0.001	0.076	0.156	mm/yr
RATE SIGMA	0.013	0.012	0.027	0.035	0.018	0.021	0.026	mm/yr

Compare Frames to ITRF2014 on 01Jan05

VLBI Scale, GNSS Geocenter

	TX	TY	TZ	S	RX	RY	RZ	
OFFSET	-4.548	-1.023	-1.465	2.903	0.543	-0.053	-0.354	mm
OFFSET SIGMA	0.501	0.479	0.582	0.521	0.117	0.141	0.204	mm
RATE	-0.452	0.284	-0.216	0.153	0.001	0.076	0.156	mm/yr
RATE SIGMA	0.065	0.066	0.094	0.036	0.018	0.021	0.026	mm/yr

SLR Scale, GNSS Geocenter

	TX	TY	TZ	S	RX	RY	RZ	
OFFSET	-4.548	-1.023	-1.465	-4.118	0.543	-0.053	-0.354	mm
OFFSET SIGMA	0.501	0.479	0.582	0.072	0.117	0.141	0.204	mm
RATE	-0.452	0.284	-0.216	-0.057	0.001	0.076	0.156	mm/yr
RATE SIGMA	0.065	0.066	0.094	0.010	0.018	0.021	0.026	mm/yr

GNSS Scale, GNSS Geocenter

	TX	TY	TZ	S	RX	RY	RZ	
OFFSET	-4.548	-1.023	-1.465	3.417	0.543	-0.053	-0.354	mm
OFFSET SIGMA	0.501	0.479	0.582	0.402	0.117	0.141	0.204	mm
RATE	-0.452	0.284	-0.216	0.243	0.001	0.076	0.156	mm/yr
RATE SIGMA	0.065	0.066	0.094	0.035	0.018	0.021	0.026	mm/yr

Compare Frames to ITRF2014 on 01Jan05

GNSS+SLR+VLBI Scale, GNSS+SLR Geocenter

	TX	TY	TZ	S	RX	RY	RZ	
OFFSET	0.330	-0.277	-0.030	-3.812	0.459	-0.107	-0.370	mm
OFFSET SIGMA	0.098	0.092	0.184	0.071	0.116	0.141	0.203	mm
RATE	-0.192	0.036	0.424	-0.020	-0.010	0.074	0.175	mm/yr
RATE SIGMA	0.012	0.012	0.025	0.009	0.018	0.021	0.026	mm/yr

DORIS+GNSS+SLR+VLBI Scale, DORIS+GNSS+SLR Geocenter

	TX	TY	TZ	S	RX	RY	RZ	
OFFSET	0.333	-0.301	-0.040	-3.685	0.469	-0.097	-0.386	mm
OFFSET SIGMA	0.098	0.092	0.184	0.070	0.116	0.141	0.203	mm
RATE	-0.191	0.033	0.424	-0.013	-0.009	0.076	0.173	mm/yr
RATE SIGMA	0.012	0.012	0.024	0.009	0.018	0.021	0.026	mm/yr

Summary

Results
GNSS scale closer to VLBI than SLR
GNSS geocenter close to SLR
All offsets less than 5 mm
All drifts less than 0.5 mm/yr
No simple test to pick a best frame at this level

Future frame improvements
Include independent GNSS geocenter and scale estimates
Frequent updates at the product level using time series approach
Frequent updates at the observation level using time series approach

GipsyX work in progress
Observation level combinations can include space ties
GipsyX adding multi-GNSS, SLR, DORIS, and VLBI capabilities
Haines et al. already experimenting with observation level GNSS+SLR