GNSS-Based Processing at the USNO: Incorporation of GLONASS Observations

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Purpose

- Describe Experimental Processing of Multi-GNSS Based Rapid-like Product
- To Investigate Advantages and Drawbacks of Multi-GNSS Signal Processing
- Future Plans

Software Setup & Processing

- Generated Using *Bernese 5.0 Software*
- A Priori: Most Recent Ultra-rapid GNSS Clocks and Orbits (IGV)
- 27 hour Observation Window with GLONASS Observations Used in Network and PPP Processing
- Network Processing:
  - Use Subset of the Available Stations that Define the IGS08 Reference Frame
  - 12 of 40 Possible Stations Receive GLONASS Signals
  - Estimate GNSS Satellite Orbits, EOP, Receiver- and Satellite-Clock Offsets
- Precise Point Positioning (PPP):
  - Remaining Available Stations Yield Receiver Clock Estimates
  - Network Solutions as PPP Inputs
- No Process Tuning to Account for GLONASS Signal Difference or Biases

Comparison to GPS-based Rapid Products

- Comparison of Multi-GNSS Test Case and "Control" of USNO GPS-Based Rapid Solutions to IGS Rapid Combination
  - Different Baselines Used in Each Case

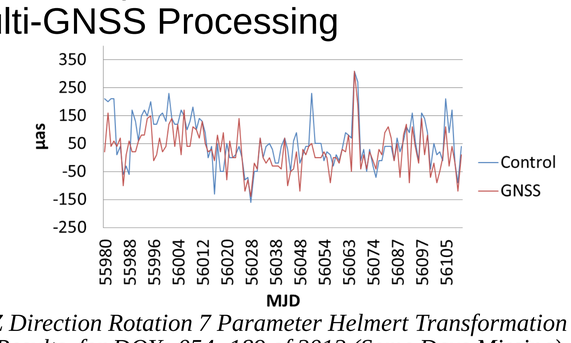
Helmert Transformation

- 7-Parameter Helmert Transformation Performed for Control and Multi-GNSS Test Case Each with Respect to IGS Rapid Orbit Combination

		Control		Multi-GNSS	
		Average	Std. Dev.	Average	Std. Dev.
Translation	X [mm]	0.26	1.77	0.41	2.00
	Y [mm]	-1.04	1.58	-0.87	1.65
	Z [mm]	0.95	2.87	0.24	2.92
Rotation	X [µas]	-31.02	299.54	3.73	335.89
	Y [µas]	44.49	181.41	43.73	186.49
	Z [µas]	57.97	86.93	24.24	72.41

7 Parameter Helmert Transformation Statistics for Orbit Solutions for DOYs 054 -189 of 2012

- Significant Improvement in Z Direction Rotation for Multi-GNSS Processing



Z Direction Rotation 7 Parameter Helmert Transformation Results for DOYs 054 -189 of 2012 (Some Days Missing)

Earth Orientation

- Difference in the Polar Motion with Respect to IGS Rapid Polar Motion Combination
- Slight Improvement in the Y Direction Polar Motion for Multi-GNSS Processing

	Control		Multi-GNSS	
	Average	Std. Dev.	Average	Std. Dev.
PM X [µas]	-81.96	149.35	-79.43	169.30
PM Y [µas]	26.97	177.95	-18.46	164.12

Polar Motion Statistics with Respect to IGS Rapids for DOYs 054 -189 of 2012

Future Plans

- Explore and Implement GLONASS Observations Processing Tuning
- Incorporate into IGS Final Troposphere Estimates (Improve Estimates at Higher Latitude Stations?)
- Incorporate into Experimental Ultra Rapid Product (Possibly to be Included into IGV Combination?)

Coordinate Repeatability

Network Stations

- Consistency Seen Over Two Week Periods

DOYs of 2012	N [mm]	E [mm]	U [mm]
152-165	10.35	10.58	10.90
166-179	11.39	8.77	11.43
180-193	12.02	11.19	13.54
average	*11.26*	*10.18*	*11.96*

Two Week Increment Coordinate Repeatability for Multi-GNSS Network Stations for DOYs 152-193 of 2012

- Subsets of Interest
  - Average Improvement for All Receivers in the North and Up Components
  - Improvement for Multi-GNSS Receivers
  - Latitude > +/- 55 degree Multi-GNSS Receivers Subset Degradation Mainly Due to Station MDVJ
  - Variable Improvement Across Subsets
    - Longer Term Study Needed

	#GLO	#Stats	N	E	U
Latitude > +/- 55 deg	3	6	-1.2%	-2.0%	-21.4%
Latitude < +/- 55 deg	5	27	4.5%	-1.5%	10.6%
Multi-GNSS	8	8	0.5%	8.2%	3.5%
All	8	33	4.2%	-1.9%	6.2%

Coordinate Repeatability Improvement for Network Station Subsets for DOYs 152-193 of 2012

PPP Stations

- Newly Incorporated into Multi-GNSS Processing Test Case (Small Data Set)

DOYs of 2012	N [mm]	E [mm]	U [mm]
166-179	13.21	11.44	31.35
180-193	10.08	8.75	12.90
average	*11.64*	*10.10*	*22.12*

Two Week Increment Coordinate Repeatability for PPP Stations for DOYs 166-193 of 2012

Conclusions

- GLONASS Signal Processing Integrated into Non-operational Rapid-like Product
- Impact in the Z-direction Helmert Rotation
- Network Coordinate Repeatability Shows Improvement in North and Up Directions
- Process Tuning Needed for Using GLONASS Data

USNO GPS-based Products Available Online: ftp://maia.usno.navy.mil/GPS/

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