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GLONASS Inter-Frequency Bias and PPP Ambiguity Resolution across Inhomogeneous Receivers

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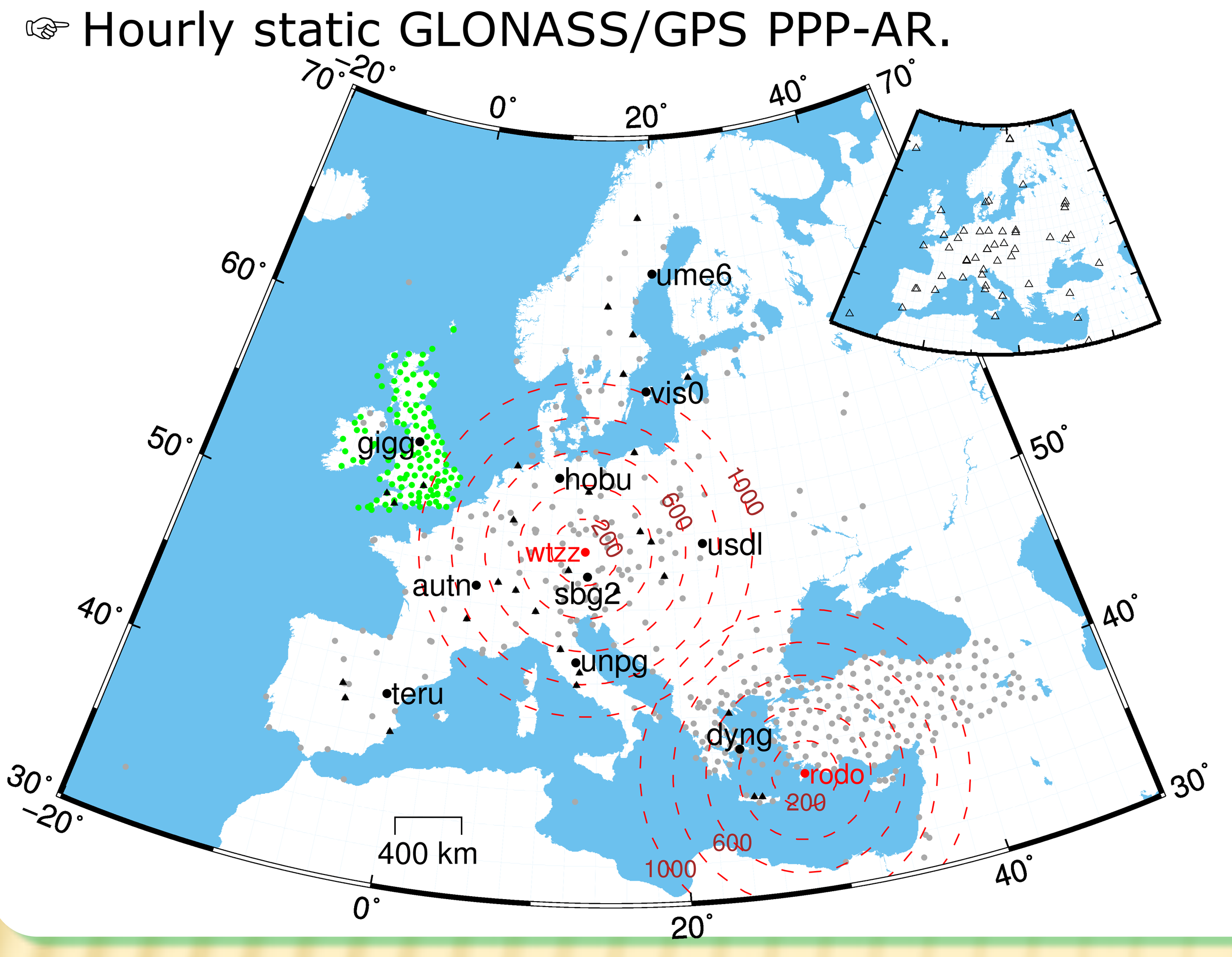
Abstract

- GLONASS PPP ambiguity resolution (PPP-AR) is difficult because
  ① Satellites do not share the same frequencies;
  ② Pseudorange inter-frequency biases (IFBs) vary with manufacturers, antennas, etc. which complicates PPP-AR over diverse receivers.
- We propose introducing ionosphere data to enable PPP-AR, and validate it using 550 Europe sites and global ionosphere maps (GIMs).
- Hourly PPP-AR can reach comparable performance to GPS PPP-AR.
- GIMs have a modest accuracy of only 2-8 TECU in vertical which confines PPP-AR to an approximately 800x800 km area in Europe.
- Details in "GLONASS fractional-cycle bias estimation across inhomogeneous receivers for PPP ambiguity resolution". JoG (online)

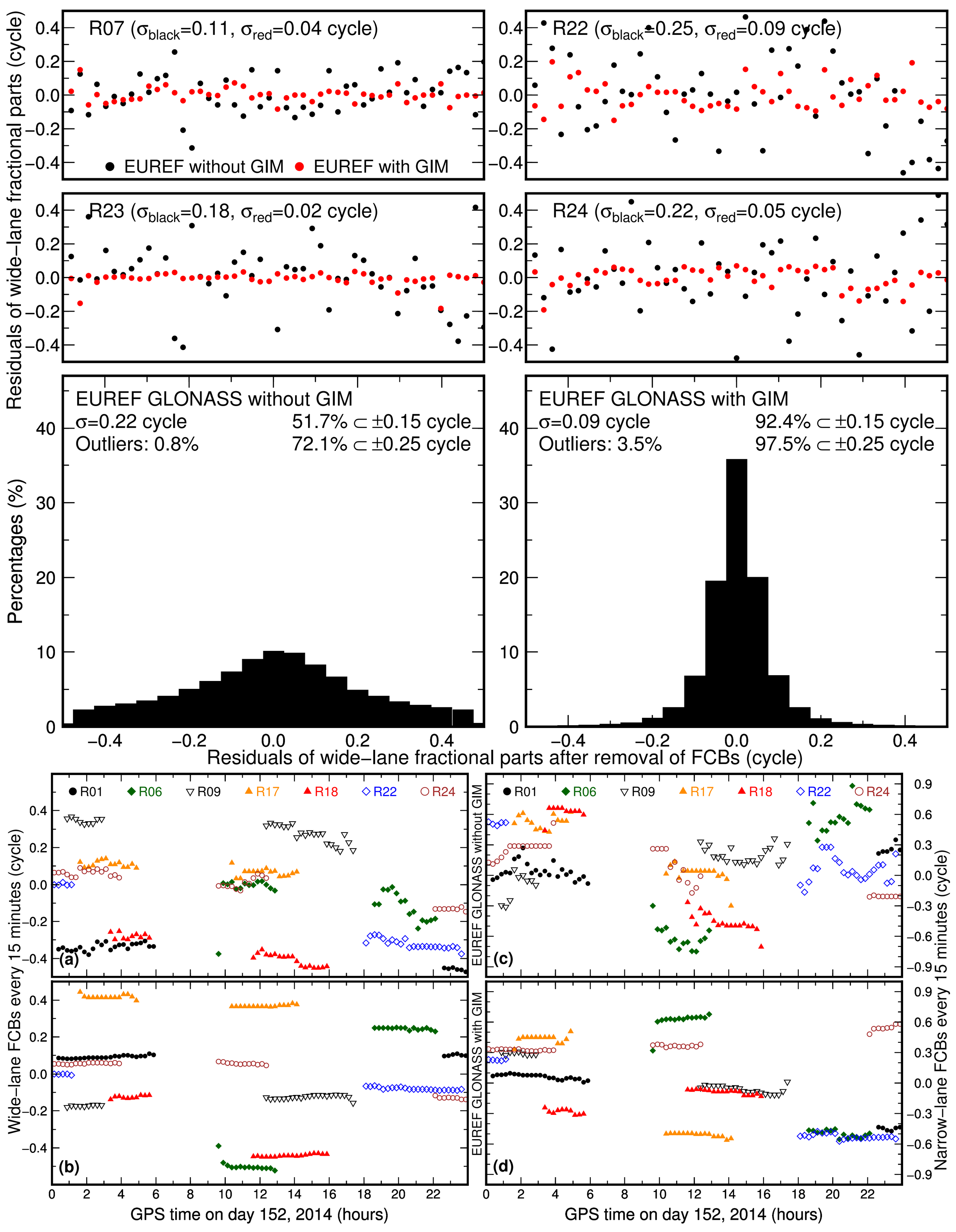
Data and validation items

- Inhomogeneous receivers (centered on WTZZ, ~800x800 km);
- Homogeneous receivers (BIGF sites in the UK, ~800x1000 km);
- To what network extent can GIMs stay effective?
- Hourly static GLONASS/GPS PPP-AR.



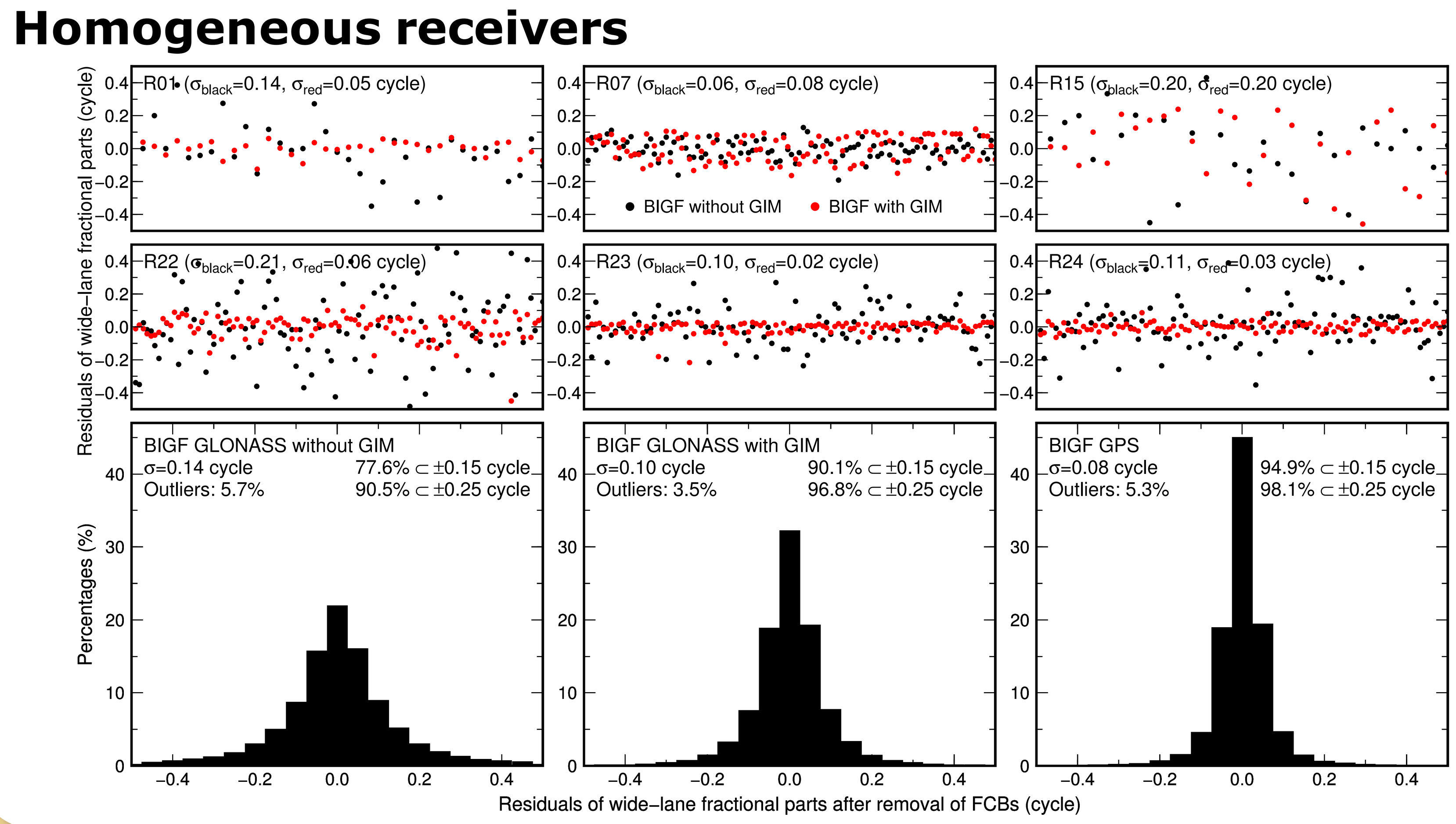
- ✓ In total 550 sites;
- ✓ 105 BIGF sites (green dots) with identical receivers;
- ✓ Concentric circles indicate areas to test GIMs;
- ✓ 40 sites (black) to test PPP-AR;
- ✓ Inset shows sites that are part of CODE sites used for GIM estimation.

Inhomogeneous receivers



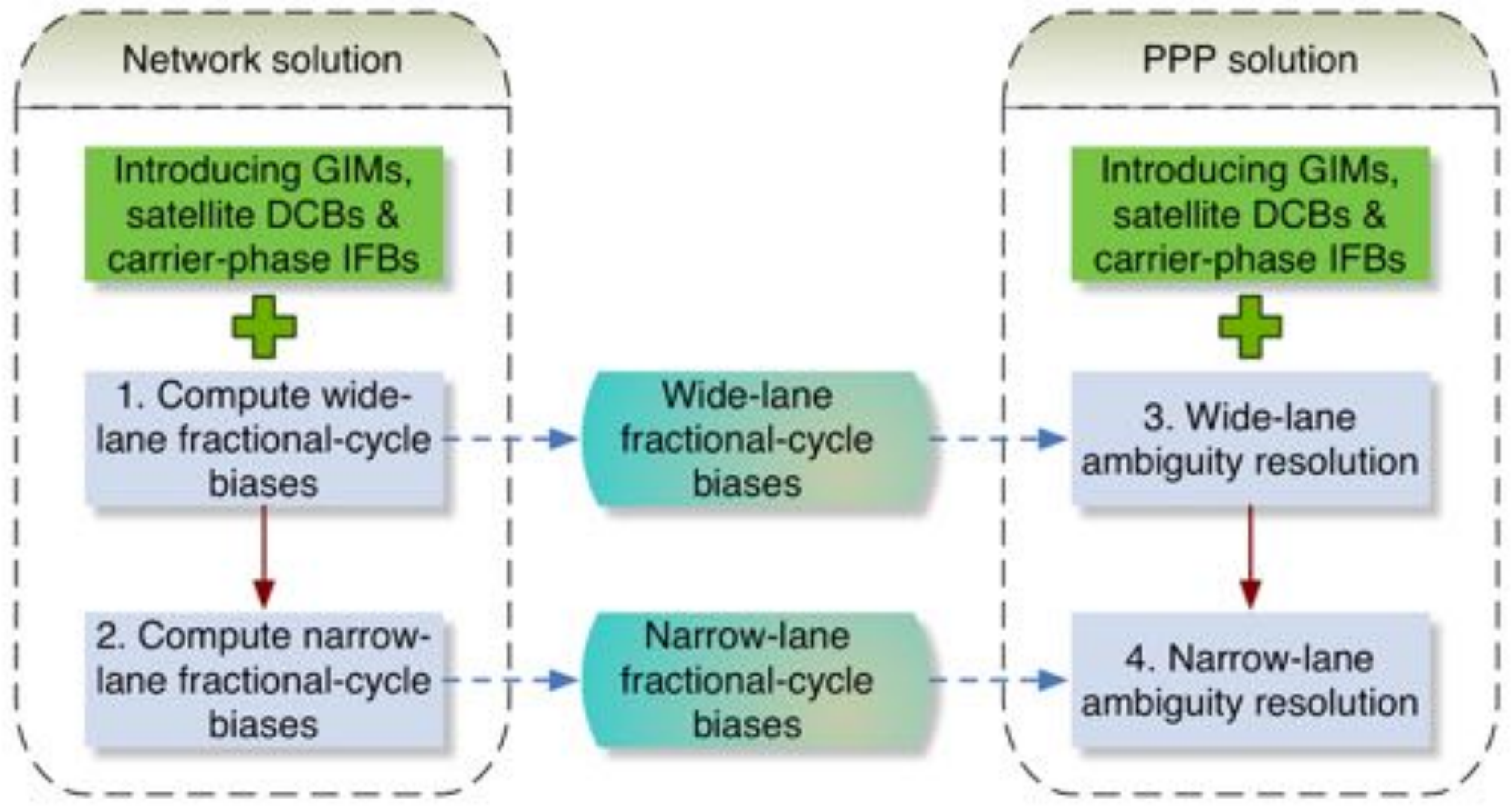
- Introducing GIMs reduces the scatter of wide-lane fractional parts;
- Wide-lane fractional parts agree well with each other within ±0.15 cycles and ensure high-quality FCBs;
- Temporal stability of wide-lane and narrow-lane FCBs are well recovered;
- Some jumps relate to low elevations and poor GIM accuracy.

Homogeneous receivers



Method description

- PPP-AR depends on the integer resolution of wide-lane ambiguities, which is achieved through Melbourne-Wübbena combination.
- However, GLONASS pseudorange are contaminated by inter-frequency biases (IFBs) that are hard to model and cannot be removed by differencing between satellites.
- So our method is
  ① Introduce GIMs and tune the relative weights between GIMs and pseudorange data in PPP;
  ② Correct for satellite DCBs (Differential Code Biases), but estimate receiver DCBs;
  ③ Correct for carrier-phase IFBs in both wide-lane and narrow-lane



To what network extent can GIMs stay effective?

Effectiveness is degraded when areas become larger.

Radii (km)		≤0.15 cycles	≤0.25 cycles	Outlier	σ (cycles)
WTZZ	200	96.7%	98.9%	1.7%	0.06
WTZZ	400	92.4%	97.5%	3.5%	0.09
WTZZ	600	89.0%	96.6%	3.1%	0.10
WTZZ	800	85.7%	95.4%	3.4%	0.11
WTZZ	1000	83.2%	94.0%	4.4%	0.12
RODO	200	94.2%	98.4%	0.0%	0.08
RODO	400	83.7%	94.4%	1.7%	0.12
RODO	600	77.1%	91.3%	3.4%	0.14
RODO	800	74.4%	90.0%	3.8%	0.15
RODO	1000	72.4%	88.8%	4.3%	0.15

Hourly static GLONASS PPP-AR

Comparable to GPS in positioning accuracy, but fixing rate is lower.

Sites	Number	Outlier	East	North	Up	Fixed amb.
GLONASS-only solutions						
UME6	2259/2856	0.7%	1.4/0.6	1.1/0.8	2.2/2.0	60.0%
VIS0	2281/2843	0.9%	1.9/0.7	1.2/0.9	2.3/2.1	65.7%
GIGG	1919/2874	0.7%	2.4/0.6	1.3/0.7	2.6/1.9	63.8%
HOBU	2224/2871	0.4%	2.1/0.5	1.3/0.7	2.6/1.8	71.5%
USDL	1967/2752	0.1%	2.4/0.7	1.3/0.6	2.9/1.9	69.5%
SBG2	1949/2844	1.1%	2.7/0.6	1.4/0.9	3.7/2.5	67.4%
AUTN	1970/2819	1.0%	2.6/0.6	1.4/0.7	3.4/2.3	67.8%
UNPG	1217/2863	3.2%	3.2/1.1	1.7/1.3	4.1/3.5	45.3%
TERU	1341/2832	4.7%	3.2/0.7	1.6/0.9	4.4/3.1	52.2%
DYNG	594/2575	8.4%	3.6/0.7	1.7/1.2	4.4/3.6	34.9%
GPS-only solutions						
UME6	2846/2856	0.4%	1.9/0.4	1.3/0.5	2.3/1.8	97.0%
VIS0	2790/2845	0.6%	2.8/0.5	1.5/0.6	2.7/1.8	94.3%
GIGG	2614/2874	0.5%	3.0/0.5	1.6/0.6	3.4/2.1	84.8%
HOBU	2811/2871	1.0%	2.7/0.5	1.5/0.7	2.8/2.3	93.1%
USDL	2735/2756	0.5%	2.9/0.6	1.6/0.6	3.4/1.8	97.9%
SBG2	2797/2844	1.3%	3.3/0.5	1.7/0.7	3.9/2.0	96.5%
AUTN	2739/2819	0.8%	2.9/0.5	1.3/0.5	3.7/1.8	96.1%
UNPG	2735/2866	3.0%	3.9/0.6	2.1/0.8	5.0/2.4	92.2%
TERU	2661/2832	2.2%	3.4/0.6	1.7/0.7	4.3/2.4	91.4%
DYNG	2468/2574	1.5%	4.2/0.7	1.9/0.8	5.0/2.5	91.2%
GLONASS+GPS solutions						
UME6	2349/2856	0.0%	1.3/0.4	0.9/0.5	1.7/1.4	64.5%
VIS0	2403/2846	0.0%	1.7/0.5	1.0/0.5	1.9/1.5	71.4%
GIGG	2048/2874	0.0%	1.9/0.5	1.0/0.5	2.1/1.5	70.2%
HOBU	2358/2871	0.1%	1.7/0.4	1.0/0.6	2.0/1.6	76.4%
USDL	2115/2756	0.0%	1.7/0.6	1.0/0.5	2.2/1.5	75.1%
SBG2	2178/2844	0.1%	1.8/0.5	1.1/0.6	2.6/1.8	75.6%
AUTN	2135/2821	0.1%	1.8/0.5	1.0/0.5	2.3/1.6	74.7%
UNPG	1557/2866	0.6%	2.1/0.7	1.2/0.7	3.0/2.1	64.3%
TERU	1583/2832	0.4%	2.0/0.5	1.0/0.6	2.7/1.9	64.6%
DYNG	703/2577	0.7%	2.1/0.7	1.2/0.7	2.8/2.0	48.5%