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# XXVI FIG CONGRESS

8-11 May 2018, İstanbul



Comparison of Triple Frequency GNSS Carrier Phase and Pseudorange noise using various satellite constellations.

Gethin Wyn ROBERTS, Faroe Islands  
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The use of range residuals and ionospheric residuals to calculate relative noise values in the observables

Usually techniques used to detect cycle slips

Analysis of variations due to

Satellite generation type eg GPS Block IIA, GPS Block IIF etc

Satellite orbit type eg BeiDou GEO, MEO, IGSO

Various satellite systems eg GPS, BeiDou, GLONASS, Galileo, QZSS

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## RINEX file 1991

1	OBSERVATION DATA				RINEX VERSION / TYPE
W2RINEXO V1.1	IESSG	16-DEC-91 13:50		PGM / RUN BY / DATE	
Central Greece GPS Project 1991					COMMENT
sta 60					MARKER NAME
Bingley	Group 3				OBSERVER / AGENCY
175	WM102				REC # / TYPE / VERS
136	WM102				ANT # / TYPE
4663890.7450	1879921.4090	3911786.2160			APPROX POSITION XYZ
1.3240	.0000	.0000			ANTENNA: DELTA H/E/N
1 1					WAVELENGTH FACT L1/2
4 C1	L1	P2	L2	# / TYPES OF OBSERV	
30					INTERVAL
1991 10	5	15	29	.000000	TIME OF FIRST OBS
91 10 5 19 38	.0000000	0 4 24 6 18 19			
22399677.144	-9577162.533	6 22399665.498	-7462709.290	6	
23993822.484	-1510155.432	5 23993824.368	-1176750.659	5	
21212943.503	-10651435.258	7 21212931.337	-8299771.986	6	
20041050.461	-20532352.558	6 20041035.264	-15999270.670	6	

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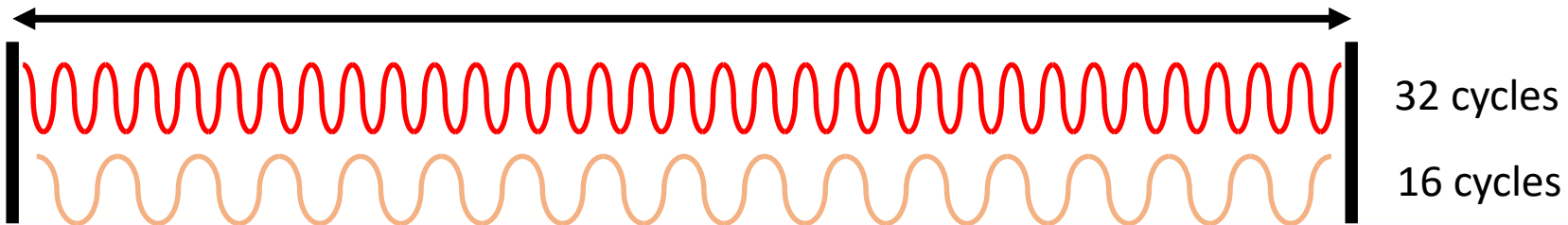




# Ionospheric Residual

- Carrier phase measure the change in ranges.
- Possible to convert into an equivalent phase measurement on another frequency
- However, systematic errors exist due to the ionosphere, which change slowly over time
- By calculating this systematic error, it is possible to detect any jumps and hence fix cycle slips
- RE-visit my PhD work from 1997

Range



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## Range Residual

$$RR = \frac{(\rho_{(i)} - \rho_{(i-1)})}{\lambda} - (\phi_{(i)} - \phi_{(i-1)})$$

## Ionospheric Residual

$$IR_a = \phi_a - \phi_b \cdot \left(\frac{f_a}{f_b}\right) + \varepsilon$$

$$\delta IR = \left( \phi_a - \left( \frac{f_a}{f_b} \cdot \phi_b \right) \right)_{(i)} - \left( \phi_a - \left( \frac{f_a}{f_b} \cdot \phi_b \right) \right)_{(i-1)}$$

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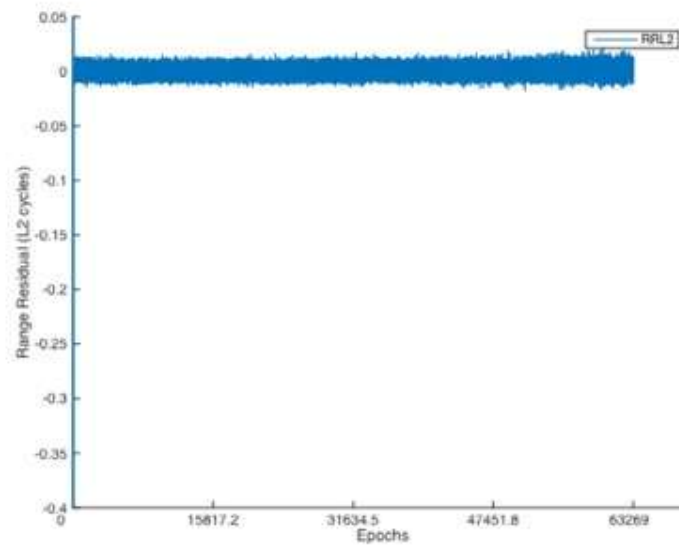
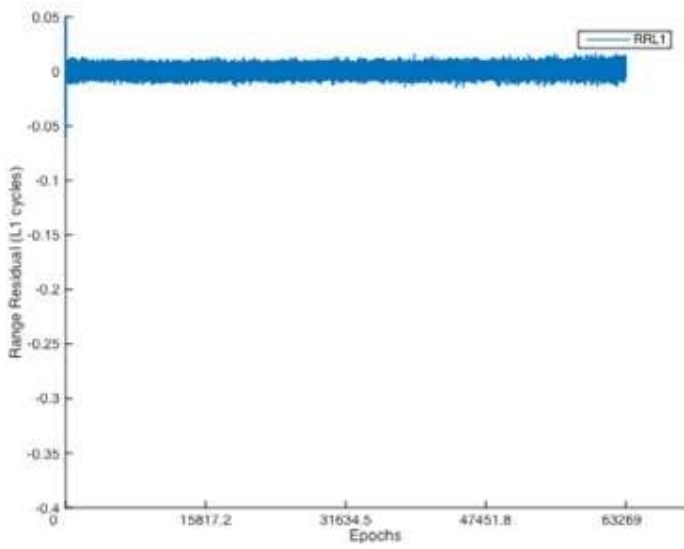
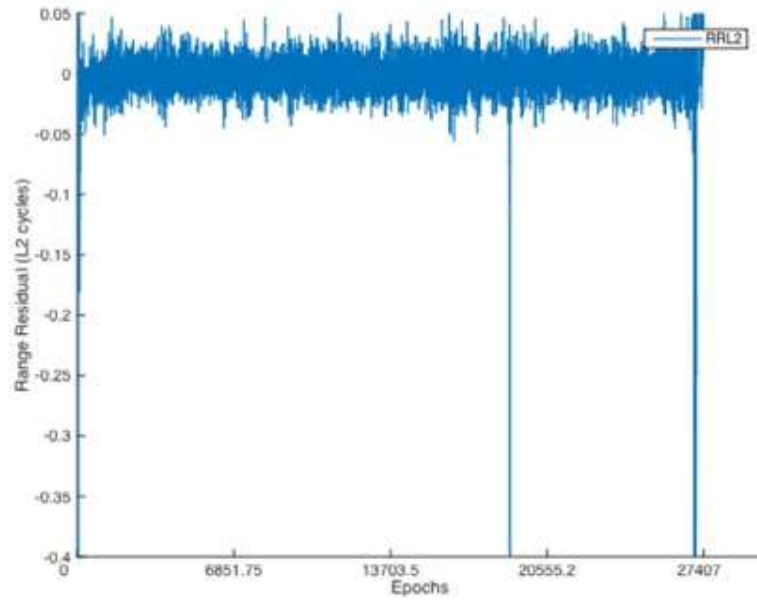
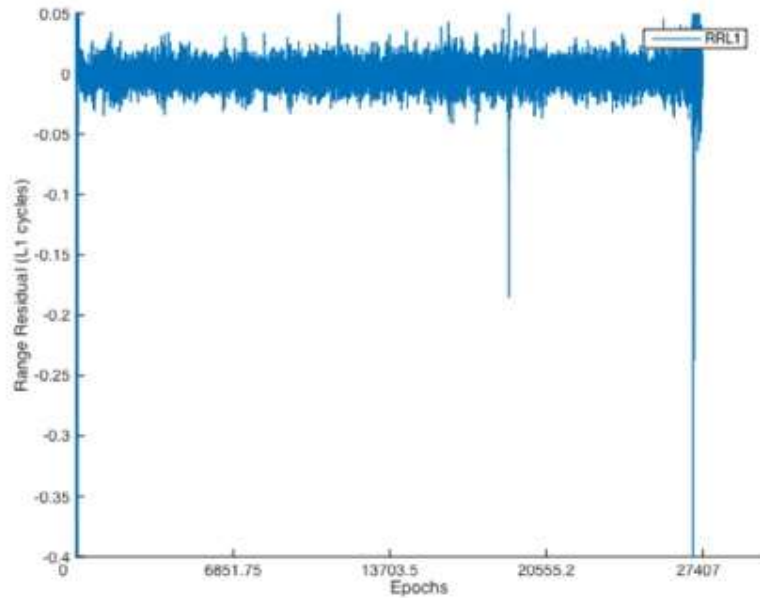


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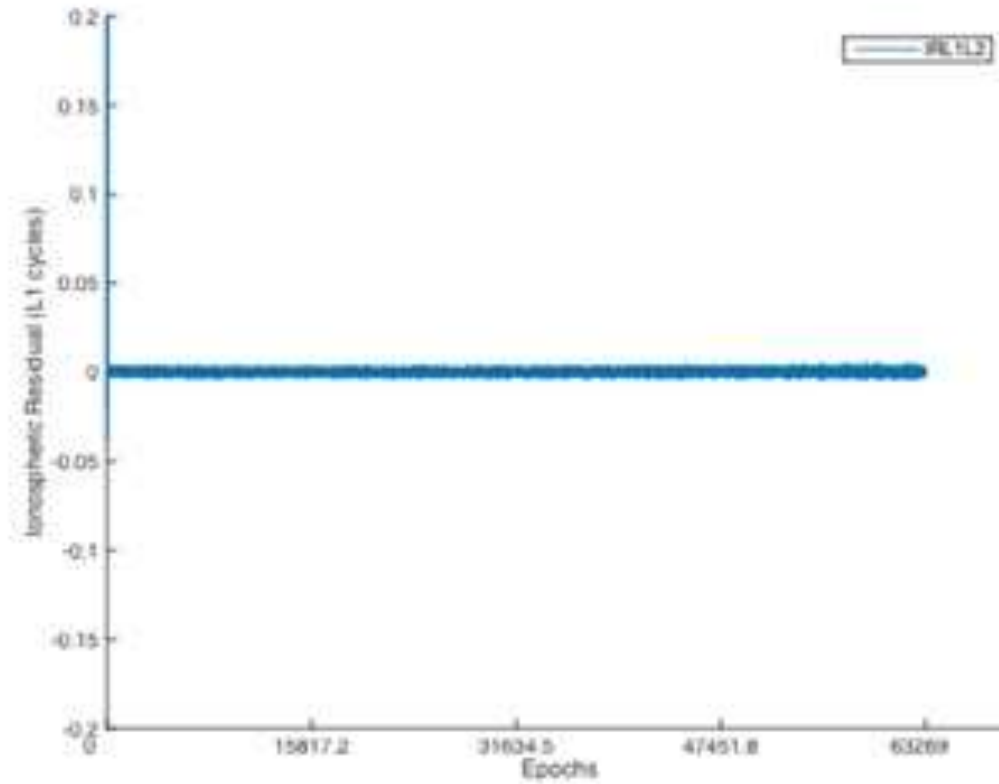
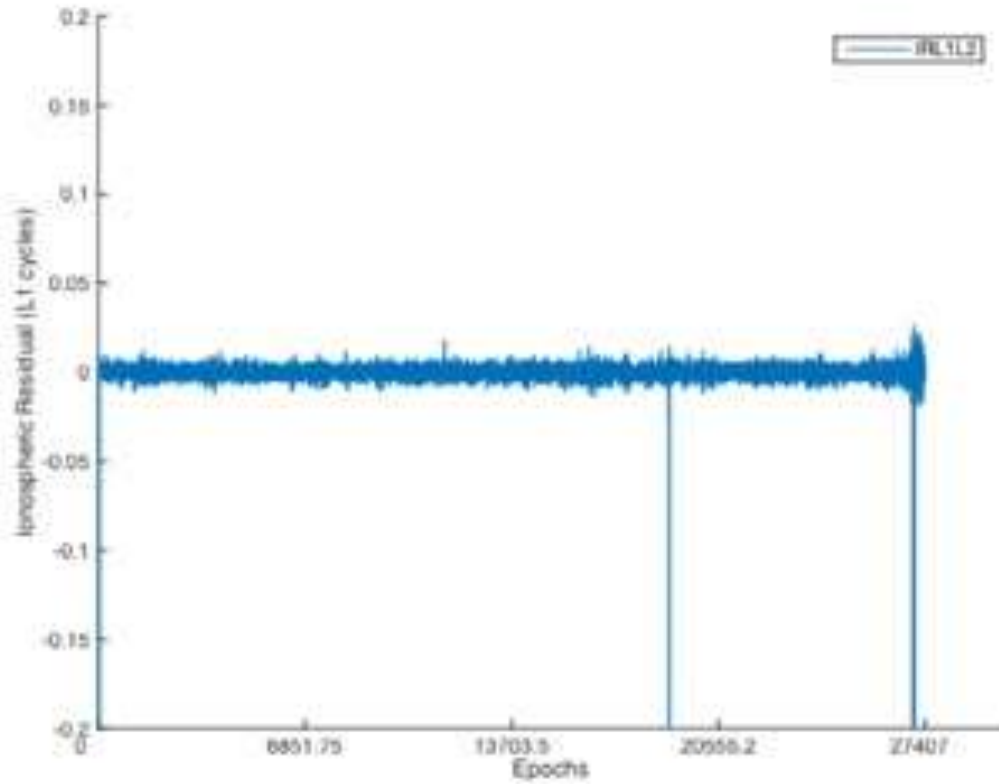
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Range residual results (top) GPS PRN32 (Block IIA satellite) and (bottom) GPS PRN14 (Block IIR satellite).



FIG



Ionospheric Residual results for the L1 and L2 combination (left) PRN32 (Block IIA) and (right) PRN14 (Block IIR).

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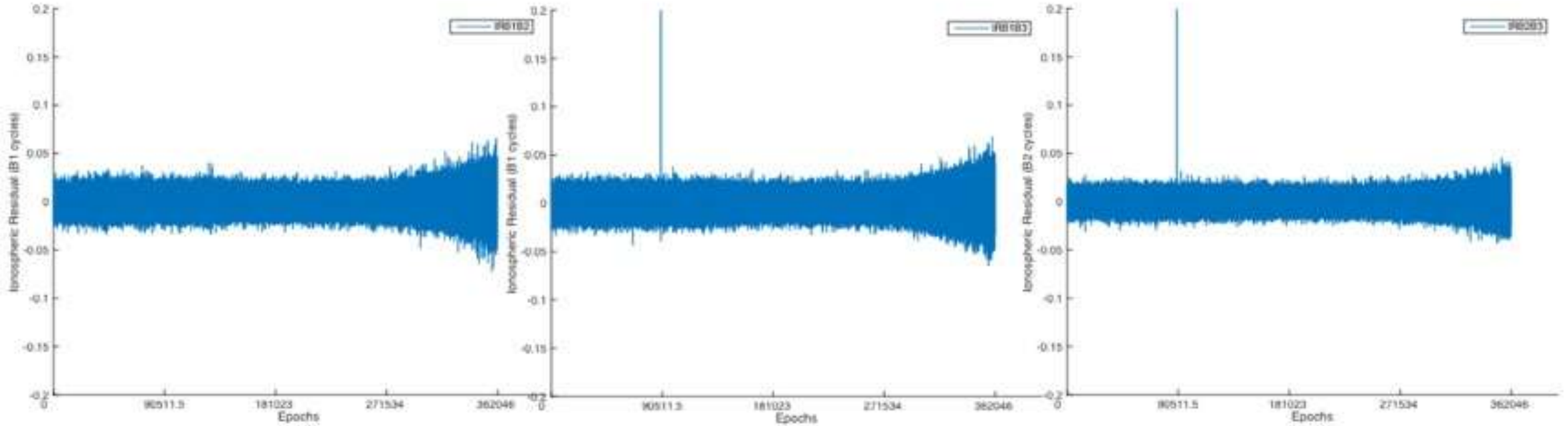
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Ionospheric Residual results for BeiDou PRN07 (IGSO) for combinations B1B2 (left), B1B3 (centre), B2B3 (right).

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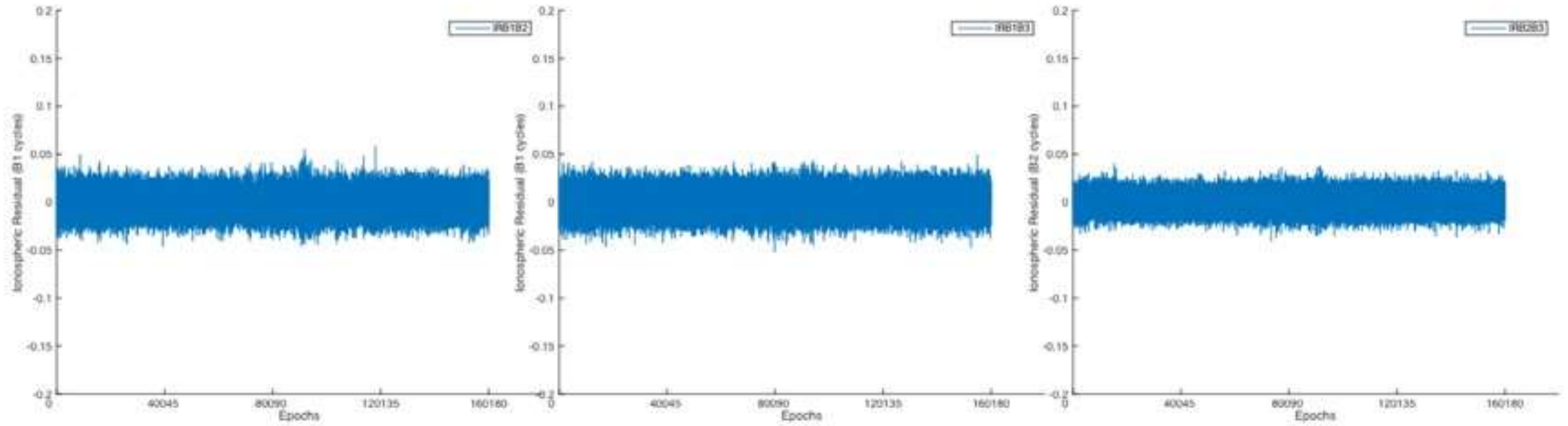


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Ionospheric Residual results for BeiDou PRN01 (GEO) for combinations B1B2 (left), B1B3 (centre), B2B3 (right).

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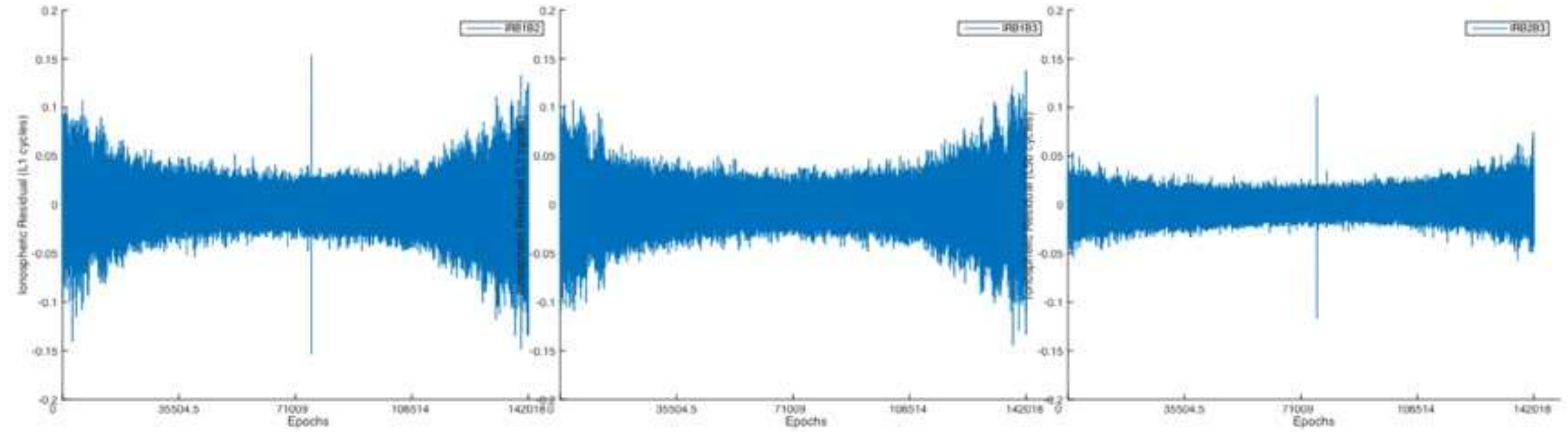


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Ionospheric Residual results for BeiDou PRN12 (MEO) for combinations B1B2 (left), B1B3 (centre), B2B3 (right).

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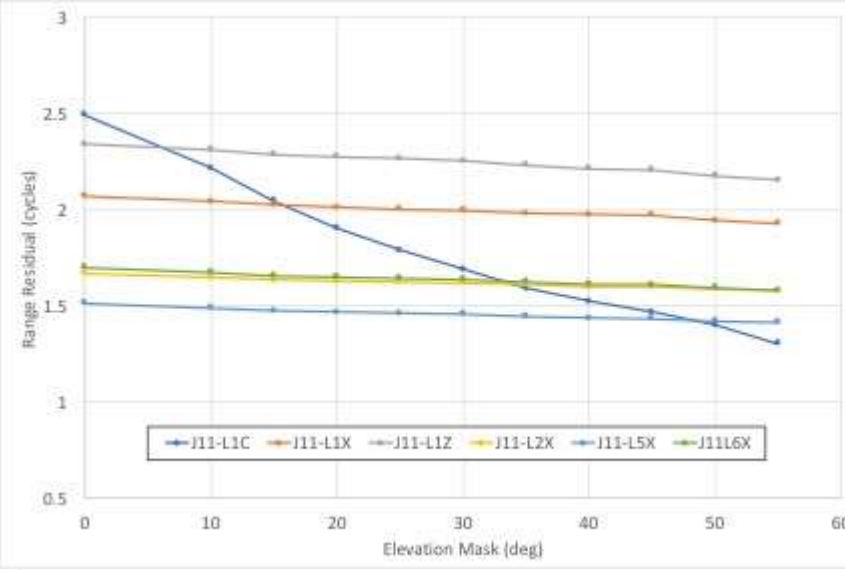
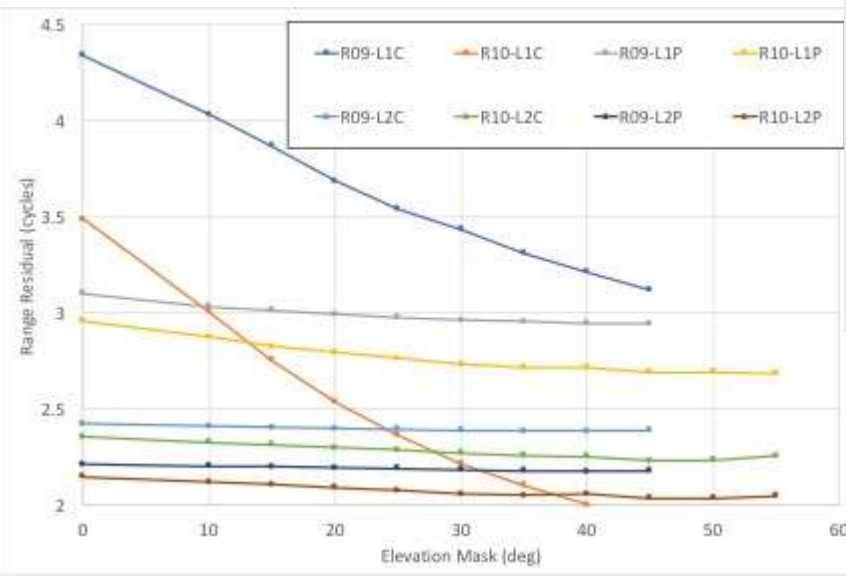
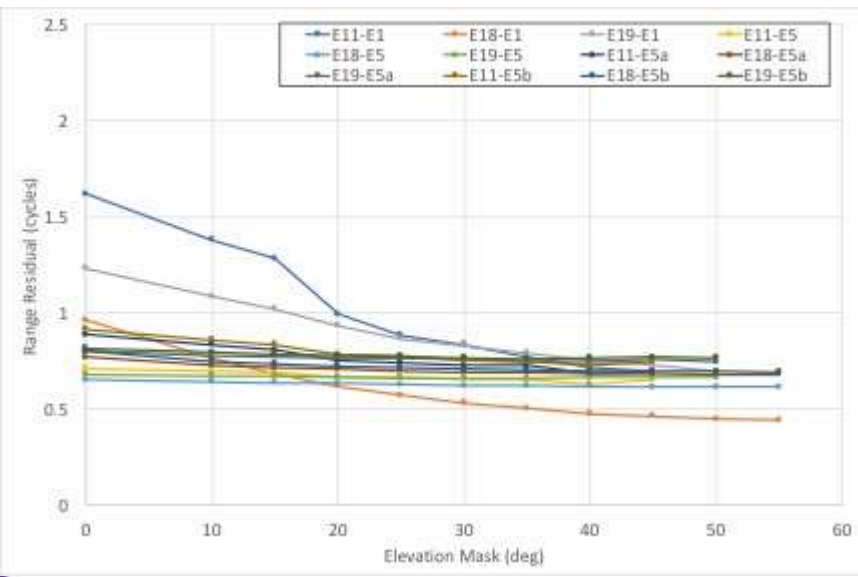
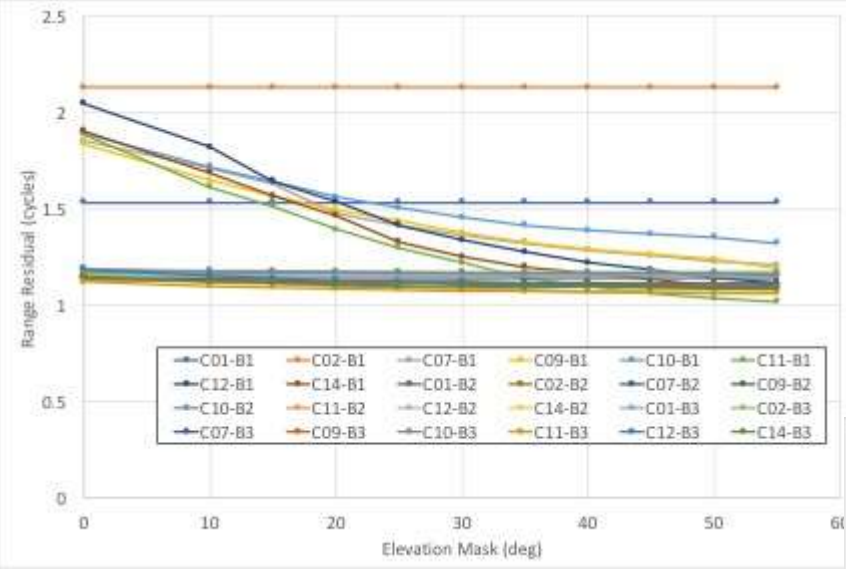
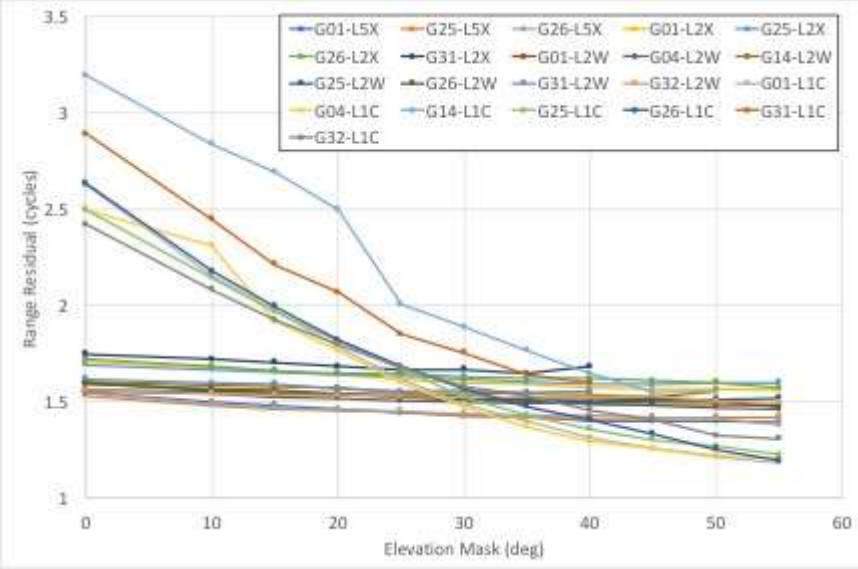
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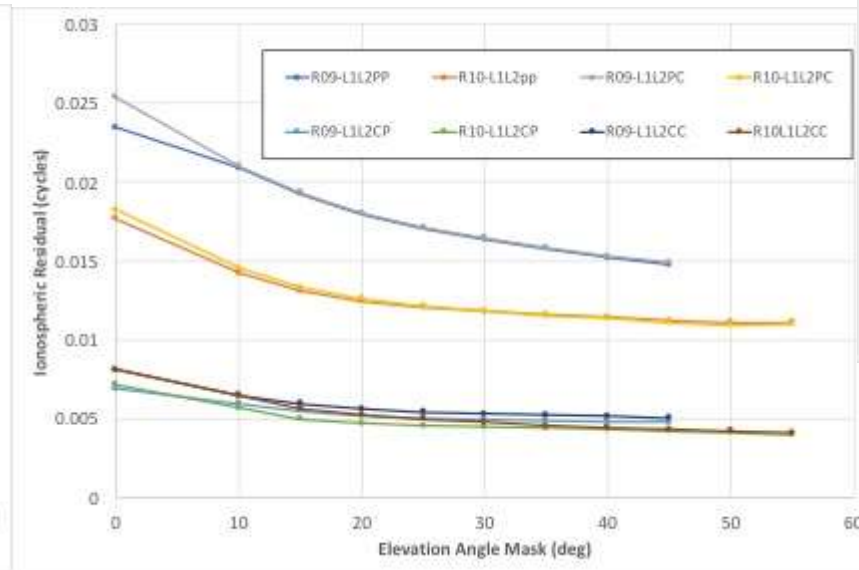
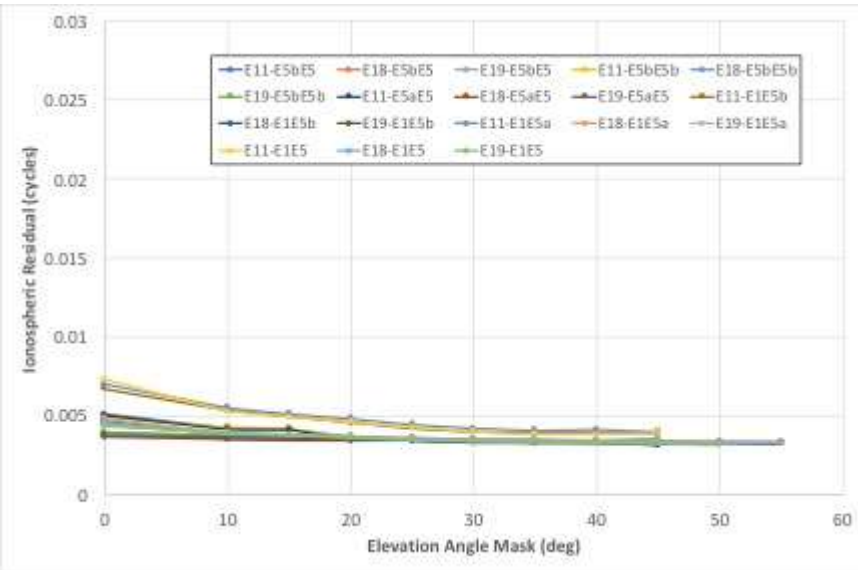
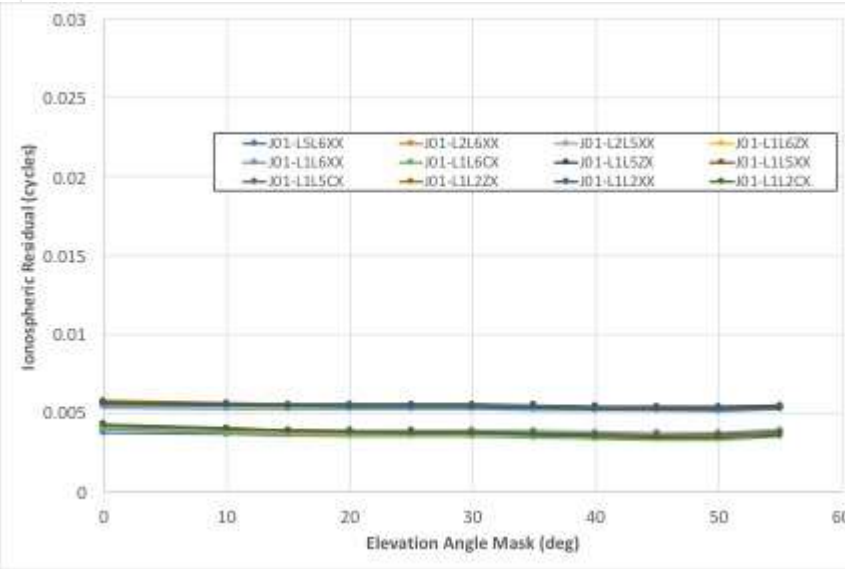
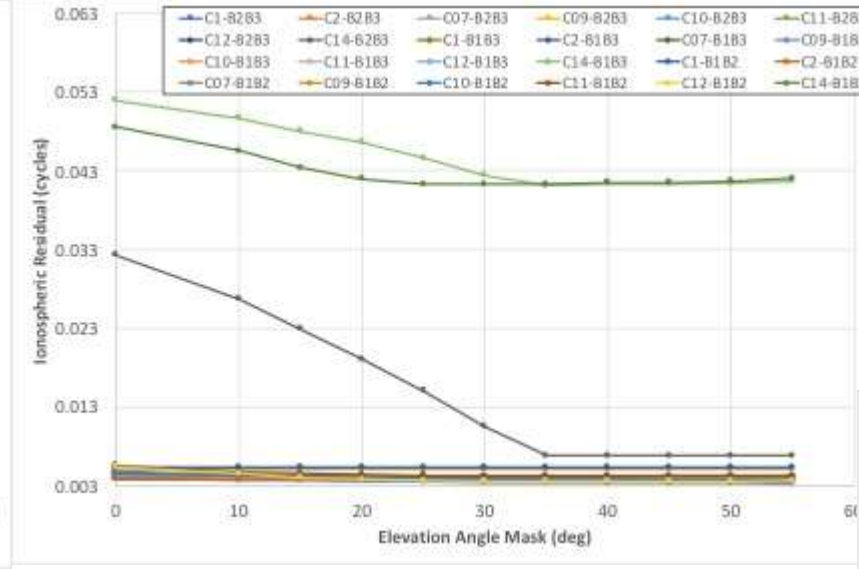
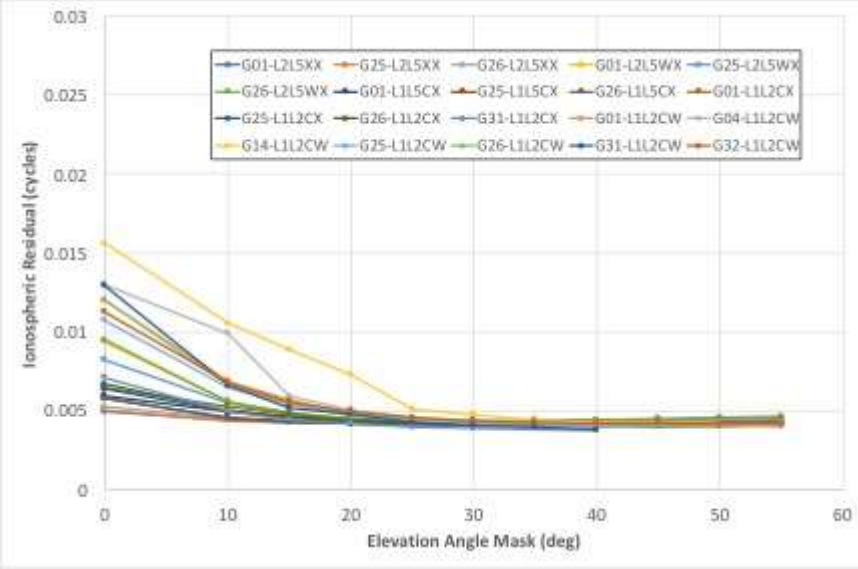
Range Residual Results for GPS (a), BeiDou (b), Galileo (c),  
 GLONASS (d) and QZSS (e).







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Ionospheric Residual Results for GPS (a), BeiDou (b), Galileo (c), GLONASS (d) and QZSS (e).





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Illustrate relative noise values for various  
GNSS various systems  
Satellite orbit types  
Satellite generation types

Also, can see the effect of low elevation data on the results

These results use data from a good GNSS environment, static data, choke ring antenna

Bad scenarios could be further investigated

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