Determination of multi-GNSS pseudo-absolute code biases and verification of receivers tracking technology

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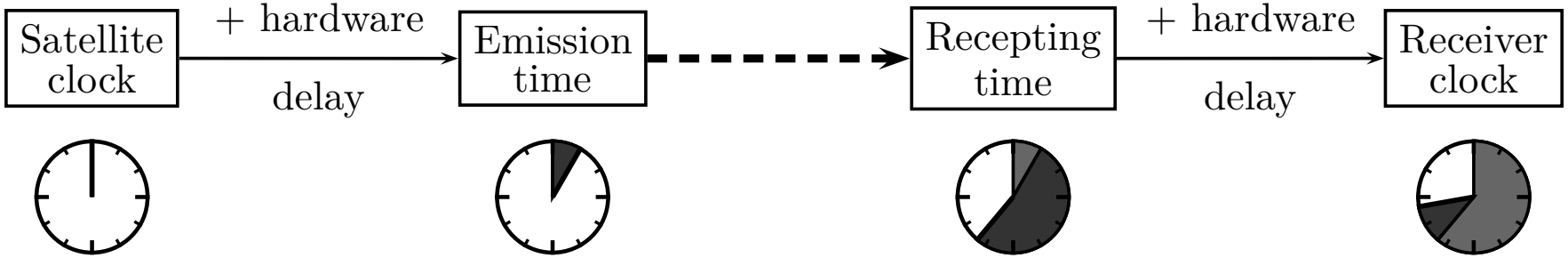
Outline

What are code biases?

Code biases are time delays within satellites and receiver caused by their hardware.



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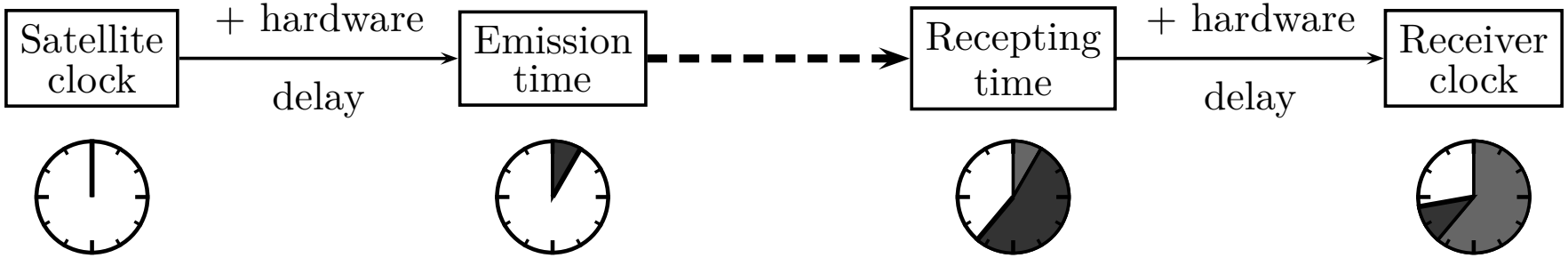

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- Frequency
- Signal type
- Receiver tracking technologies
- GNSS system

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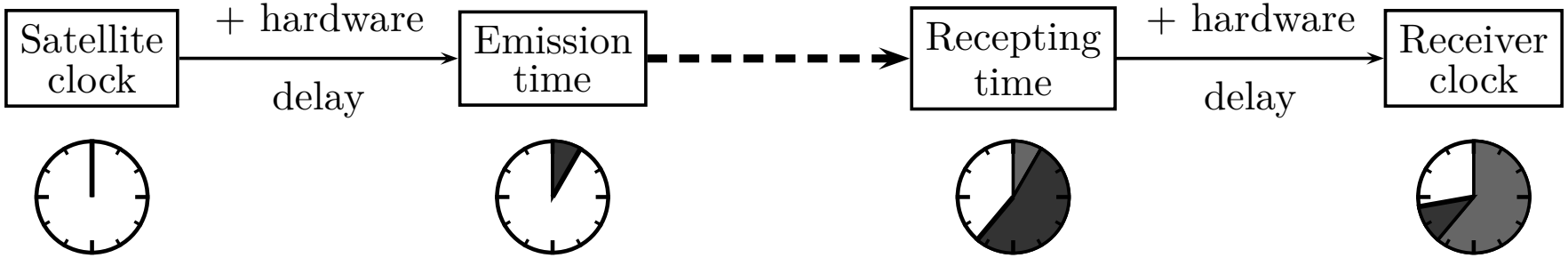

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Observable-specific Signal Biases (OSB)

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How to estimate code biases?

Methods

- Direct estimation (using ionosphere model)
- Clock analysis (ionosphere-free linear combination)
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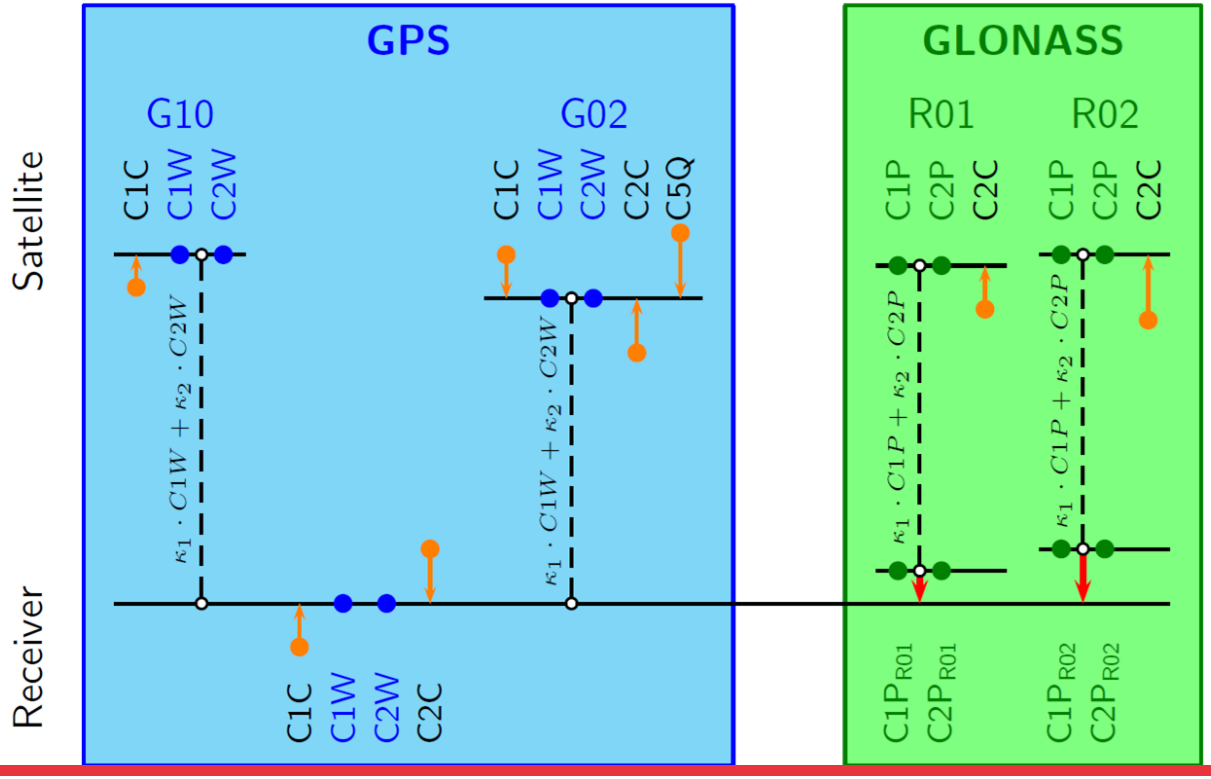

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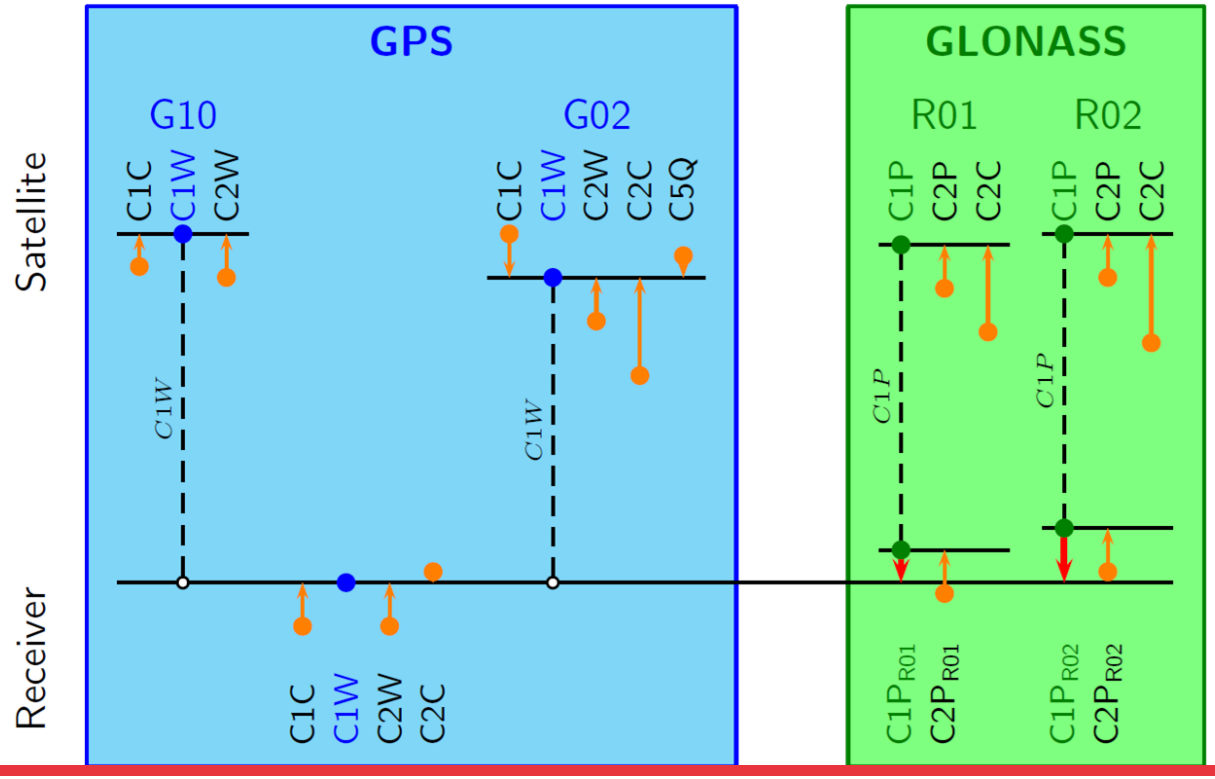

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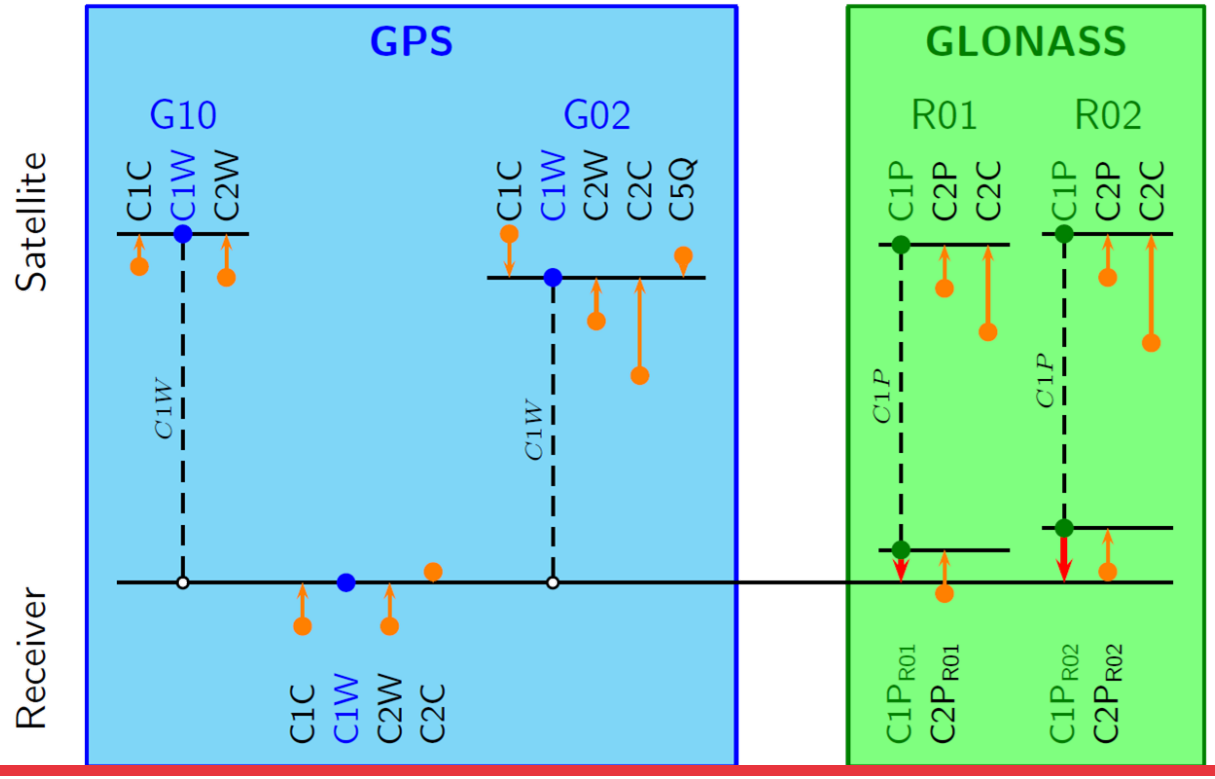
→ pseudo-absolute Observable-specific Signal Biases (OSB)



GPS/GLO/GAL/BDS OSB's

Input data

- Estimation based on over 250 IGS and MGEX stations
- RINEX3 favored over RINEX2
- Analyzed data period: November 2016

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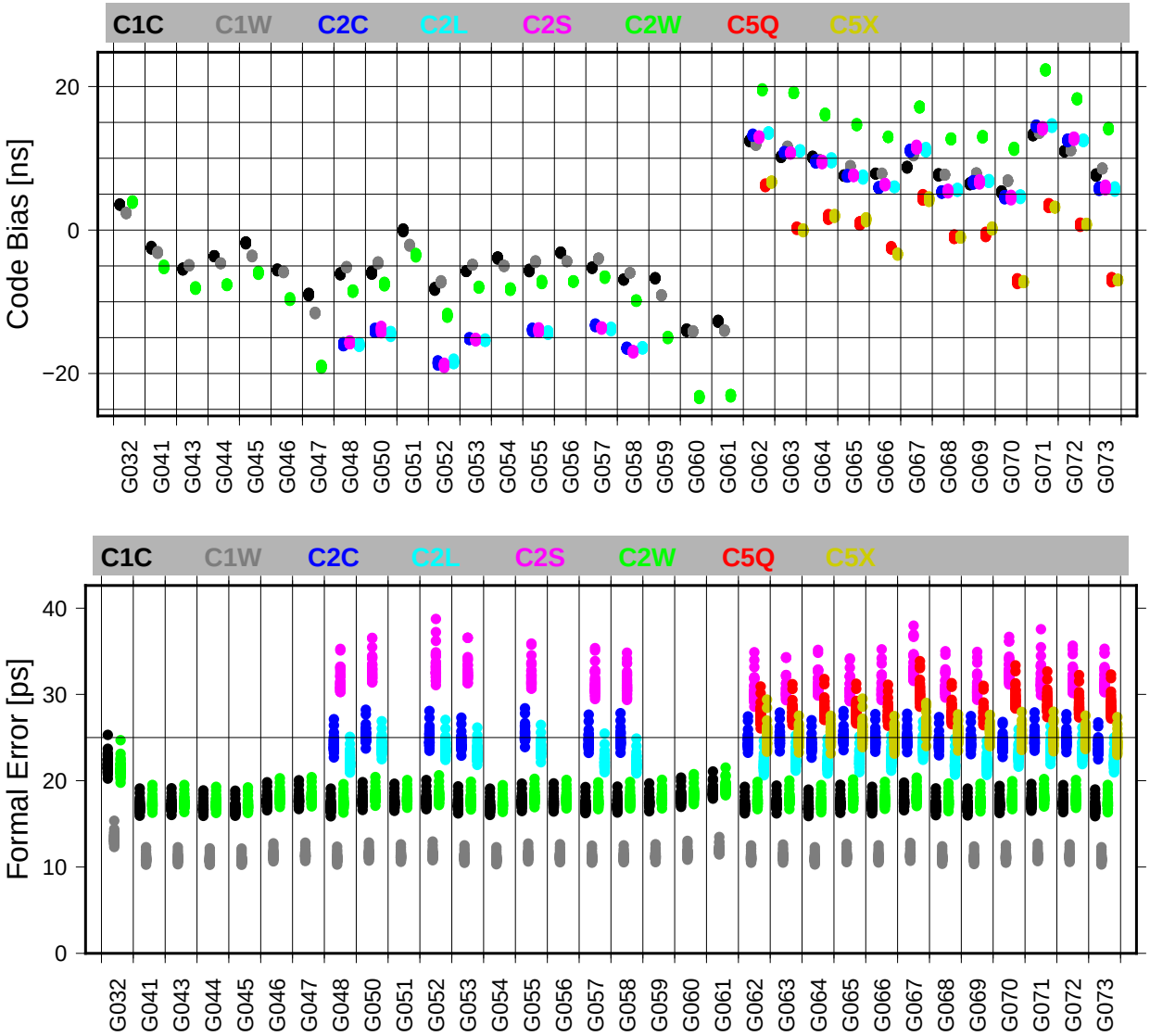
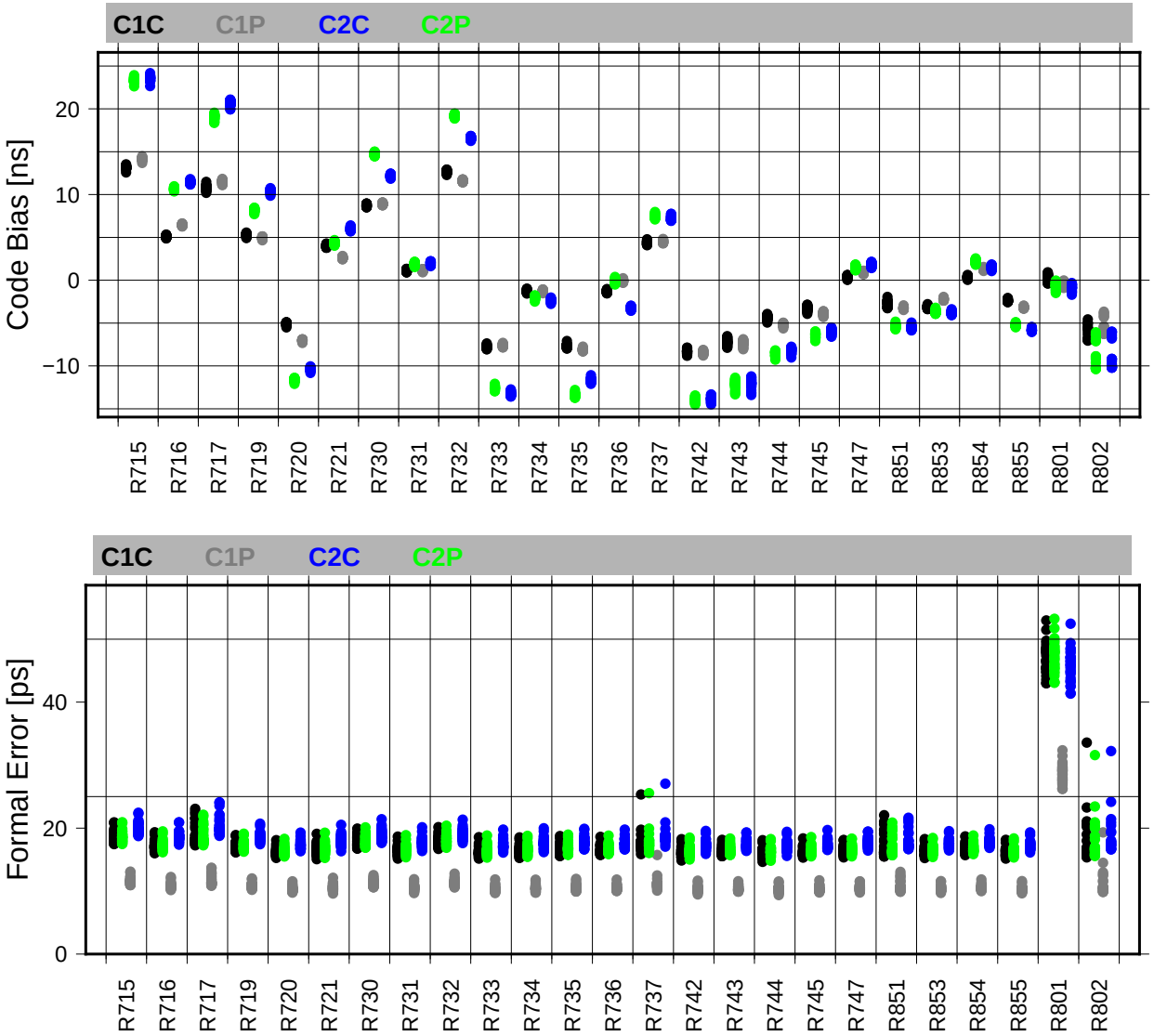
Observables

GPS	C1C C1W	C2C C2W C2L C2S	C5Q C5X	
GLONASS	C1C C1P	C2C C2P		
GALILEO	C1C C1X	C5Q C5X	C7Q	C8Q
BEIDOU	C2I	C6I	C7I	

GPS Code Biases (OSB)

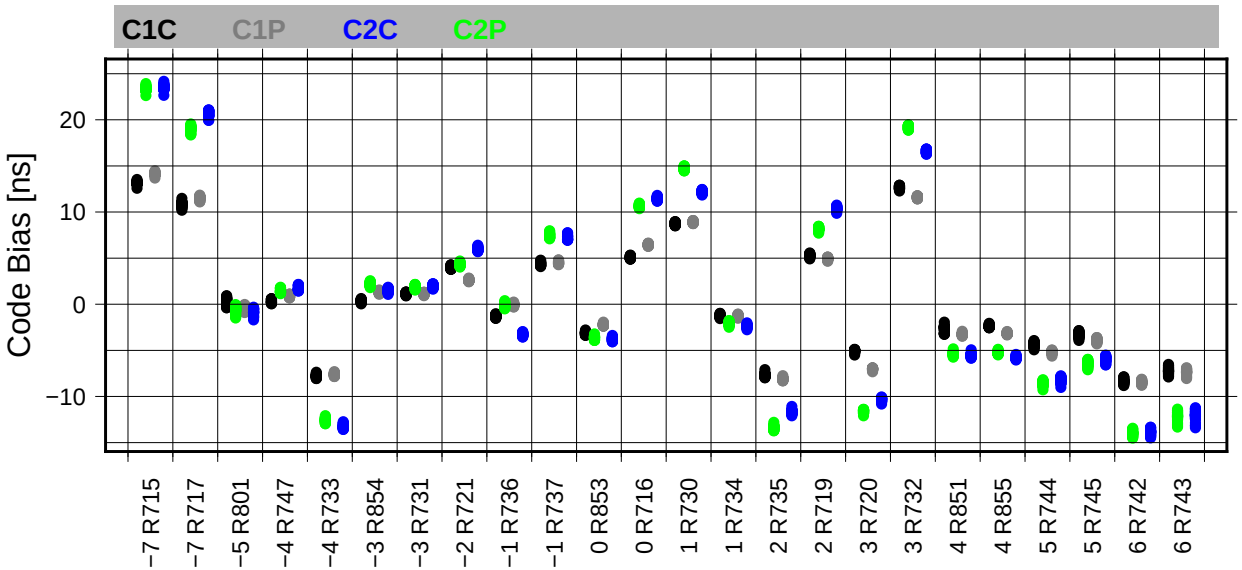


GLONASS Code Biases (OSB)



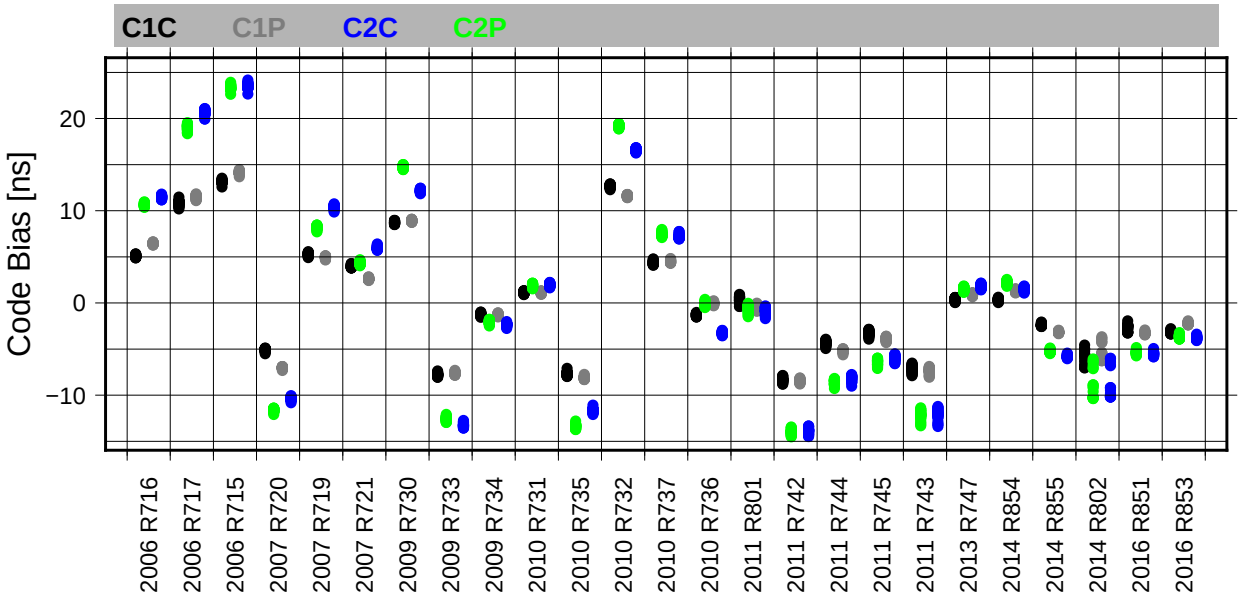
GLONASS Code Biases (OSB)

GLONASS OSB: Sorted according to their frequency number

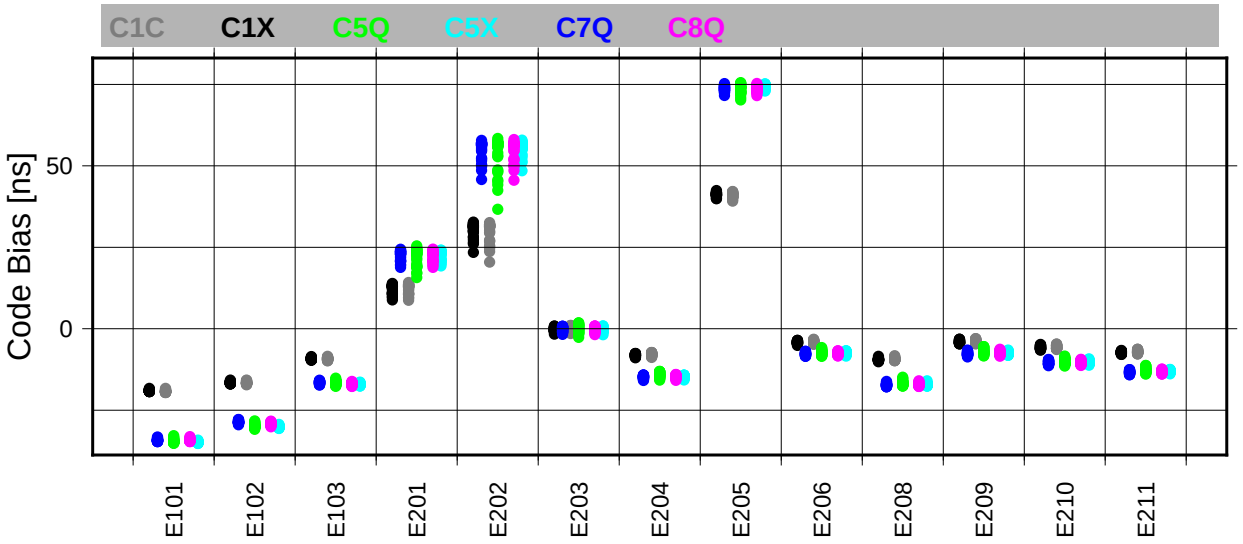


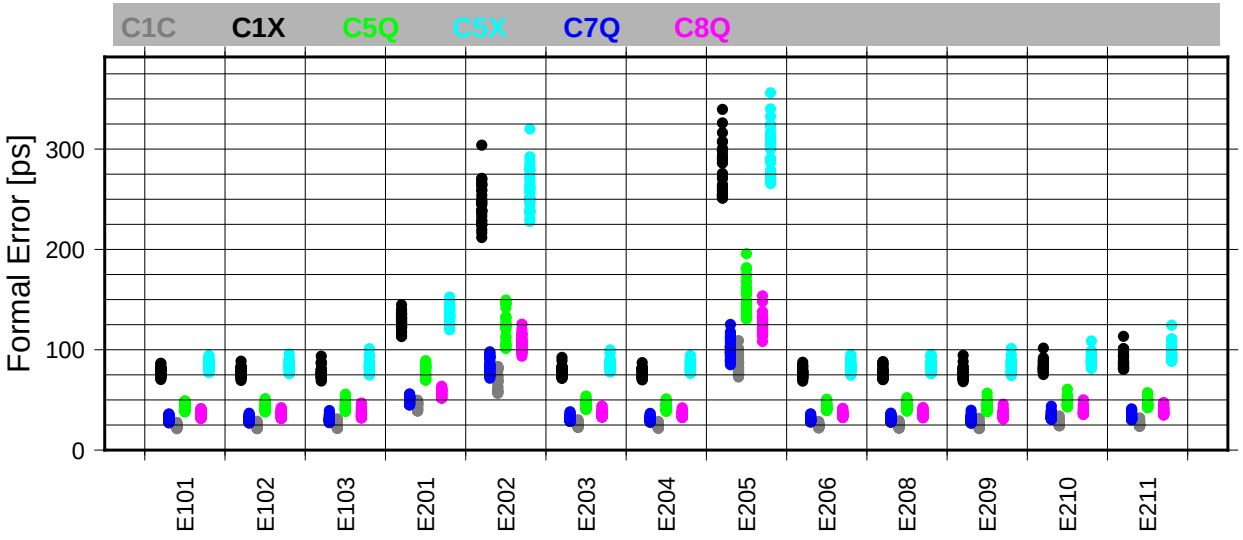
GLONASS Code Biases (OSB)

GLONASS OSB: Sorted according to their launch date



GALILEO Code Biases (OSB)

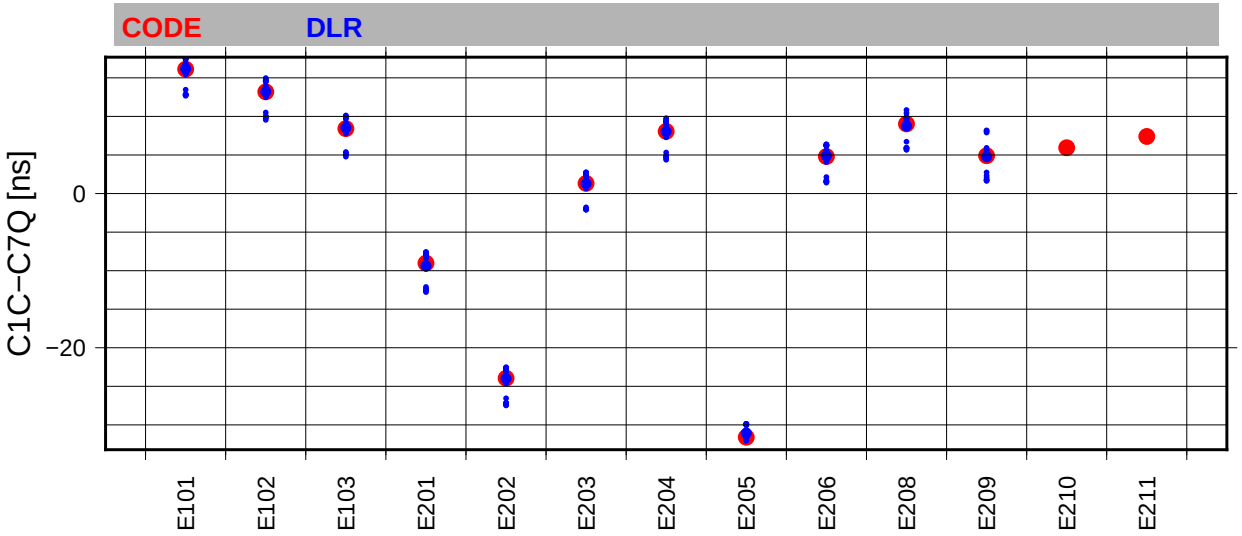




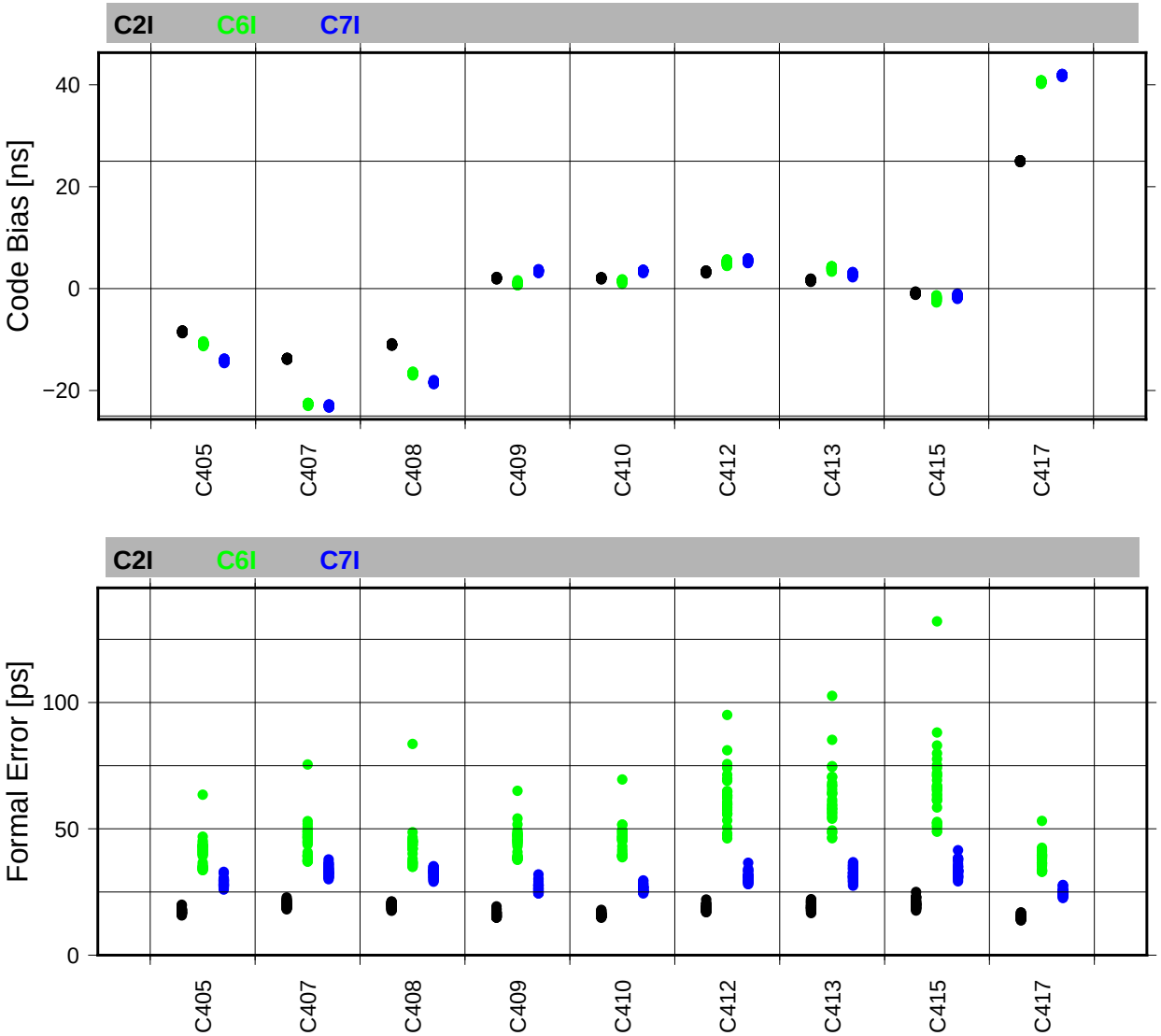
GALILEO DCB: C1C-C7Q

Comparison of differential code biases

- DLR bias solution (MGEX) for Jan-Mar 2016 [Montenbruck et. al, 2014]
- CODE solution for November 2016
- CODE DCB aligned to DLR solution



BeiDou Code Biases (OSB)



Receiver Tracking Technology Verification

Code pseudo-range equations:

$$P_{1k}^i = \rho_k^i + \quad I_k^i + T_k^i + c(\Delta\delta_k + B_{1k}) - c(\Delta\delta^i + B_1^k)$$

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Geometry free linear combination (L1-L2):

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Geometry free linear combination (L1-L2): known unknown

$$P_{LCk}^i = \left(1 - \frac{f_1^2}{f_2^2}\right) I_k^i + 1 \cdot B_{C1W_k} - 1 \cdot B_{C2W_k} - 1 \cdot B_{C1W}^i + 1 \cdot B_{C2W}^i$$

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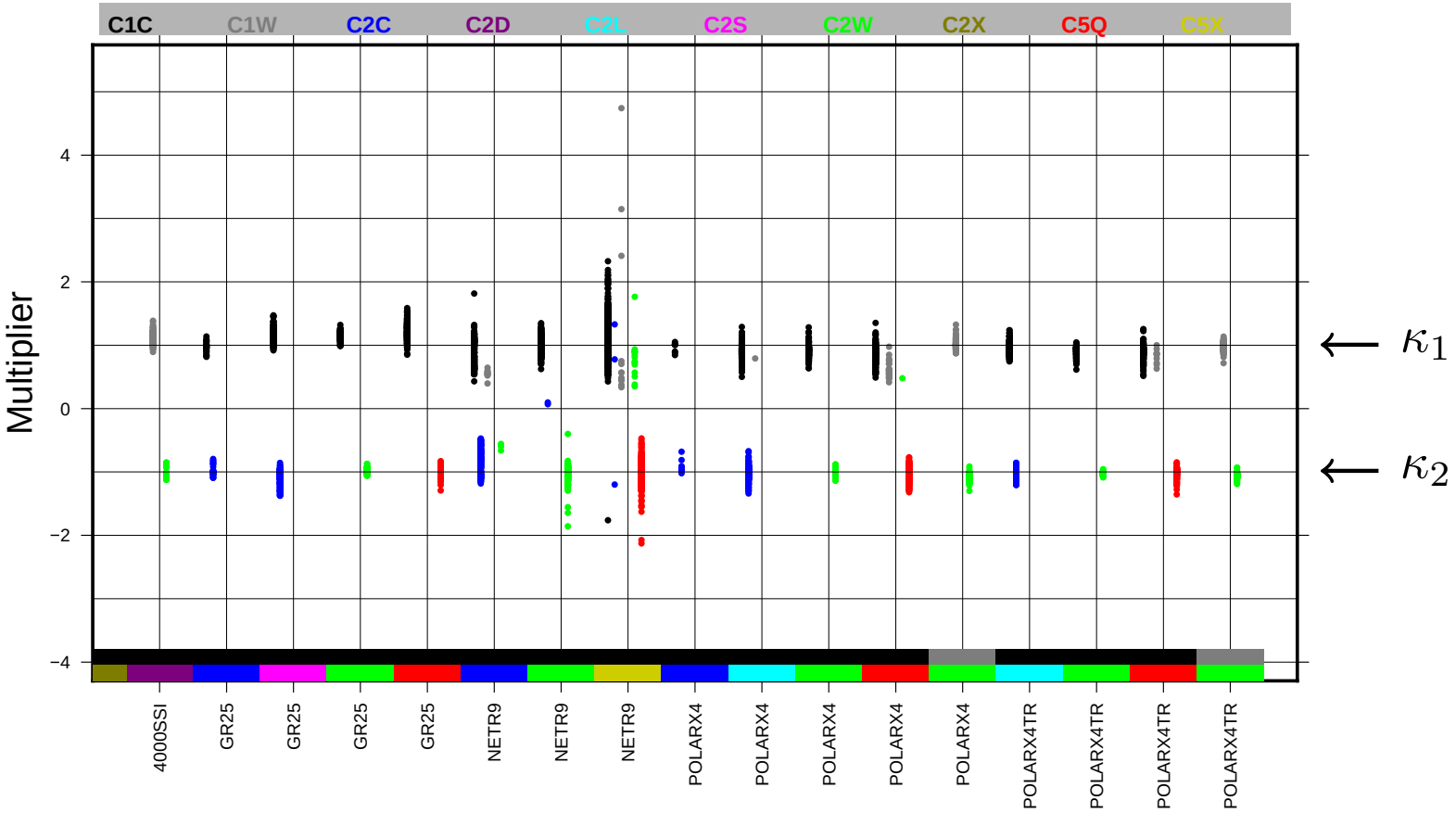
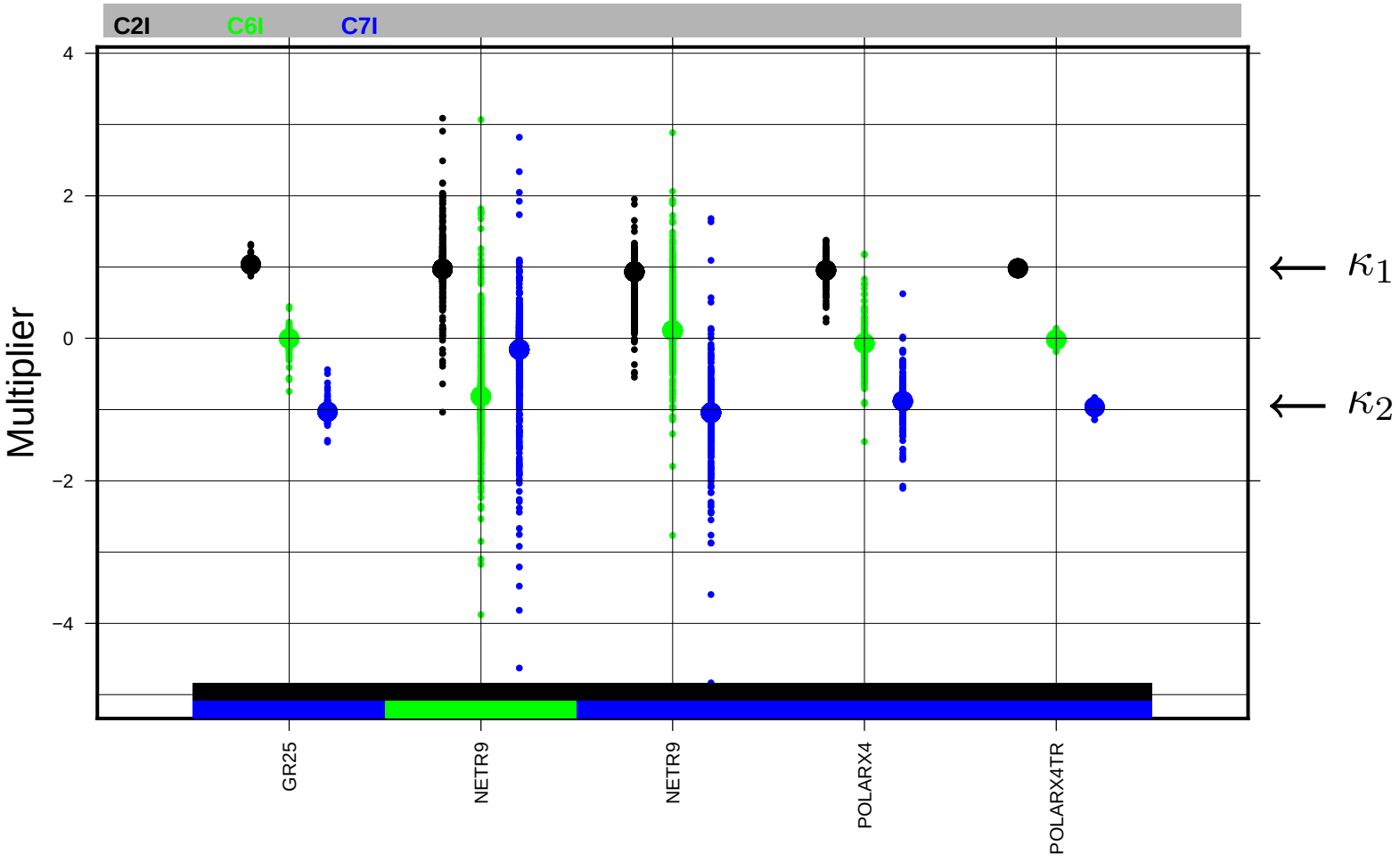
$$\begin{aligned} P_{LCk}^i \quad = \cdots \quad & -m_{C1W}^S \cdot B_{C1W}^i - m_{C1C}^S \cdot B_{C1C}^i \\ & +m_{C2W}^S \cdot B_{C2W}^i + m_{C2C}^S \cdot B_{C2C}^i \end{aligned}$$

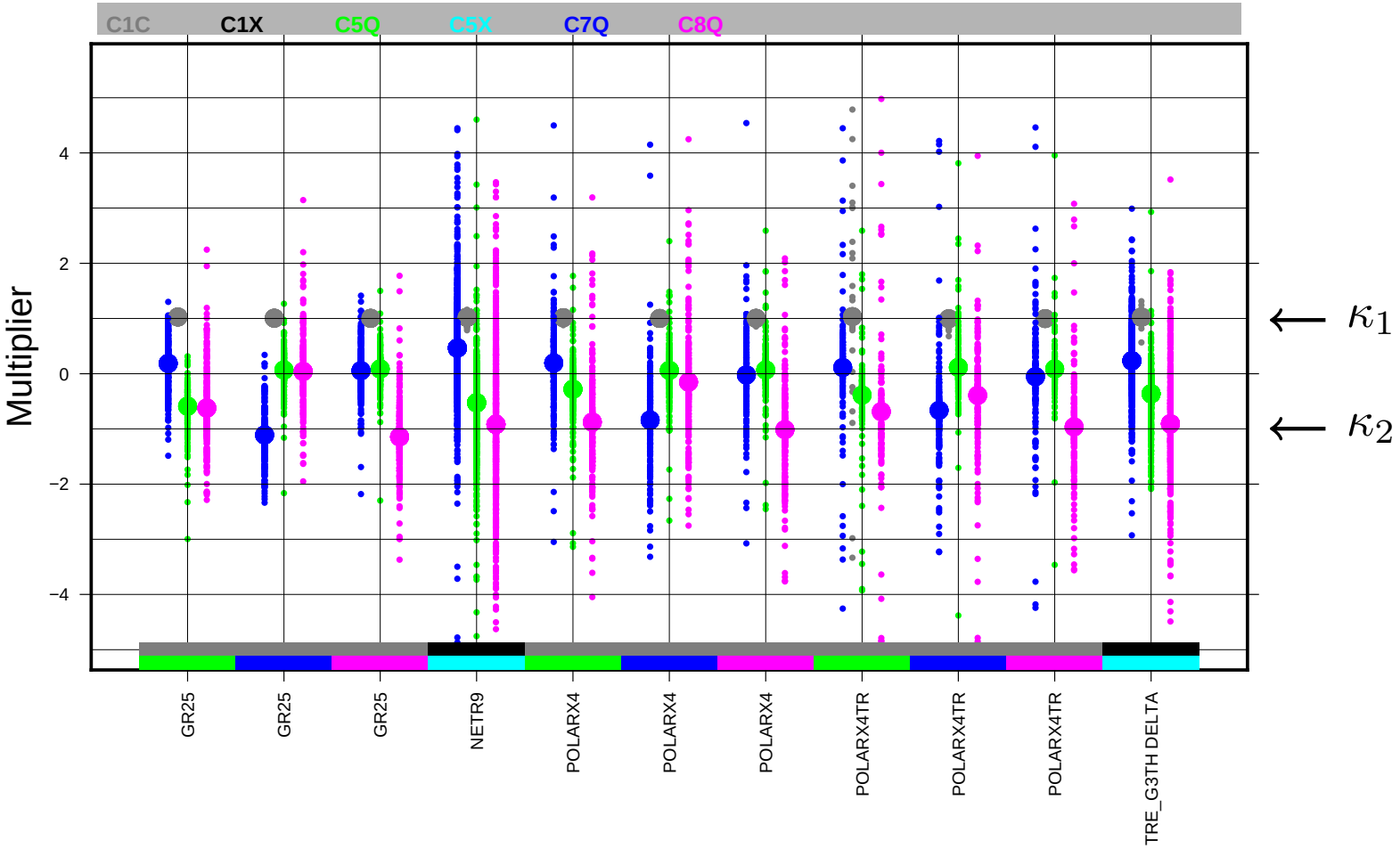
GPS Multipliers



BDS Multipliers



GAL Multipliers



Conclusion

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Receiver Tracking Technology Verification

- Based on OSB multiplier estimation (multi-GNSS capable)
- Multiplier estimation operationally done by CODE
- Multiplier depend on the satellite patterns
- GALILEO C5X patterns need further investigations, results show that they are not pure C5Q signal (RINEX3: C5X = C5Q + C5I)